Early trauma care for the severely injured:

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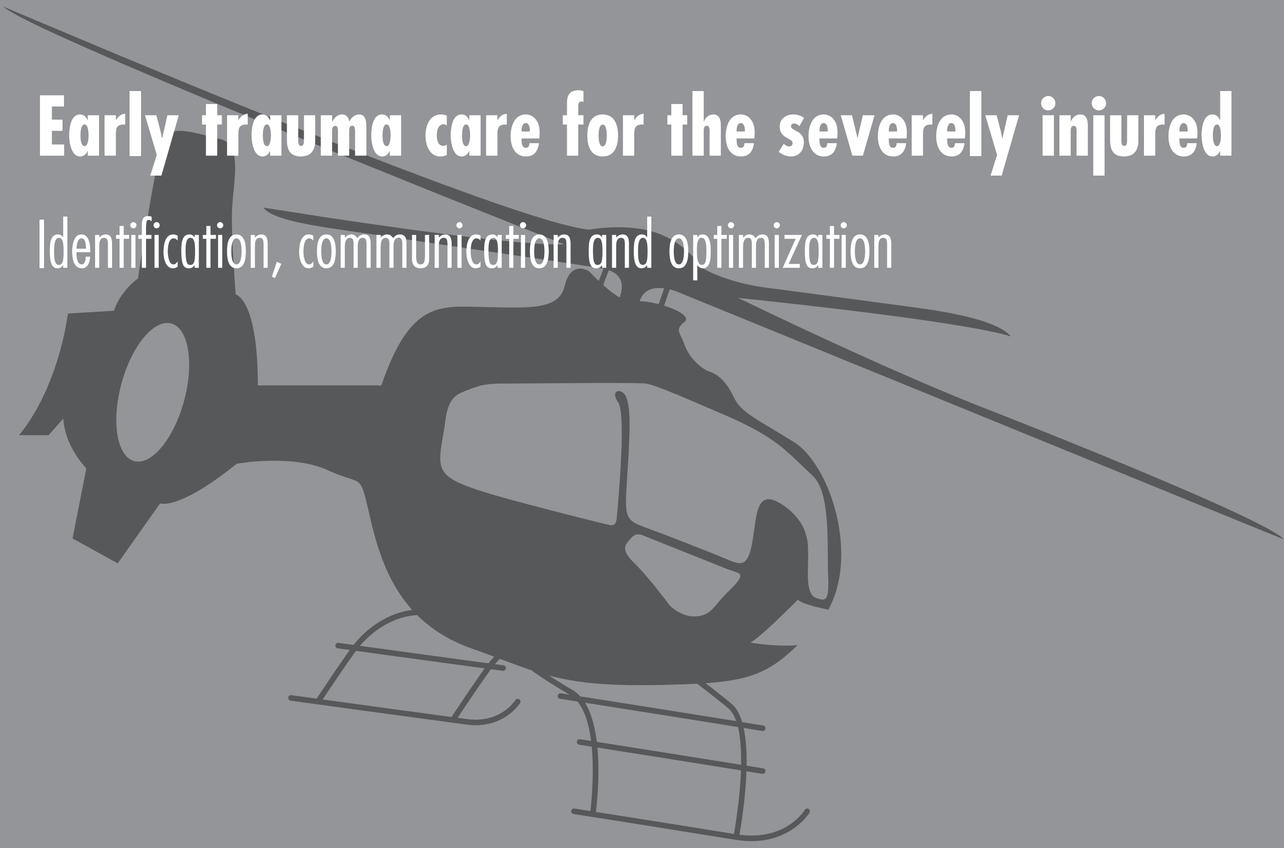
Early trauma care for the severely injured

Identification, communication and optimization



Annelieke Harmsen

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Early trauma care for the severely injured: identification, communication and optimization

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promotor: prof.dr. H.J. Bonjer

copromotoren: dr. F.W. Bloemers
dr. G.F. Giannakopoulos

“The important thing is not to stop questioning. Curiosity has its own reason for existing. “

Albert Einstein

Contents

Chapter 1

General introduction

General introduction

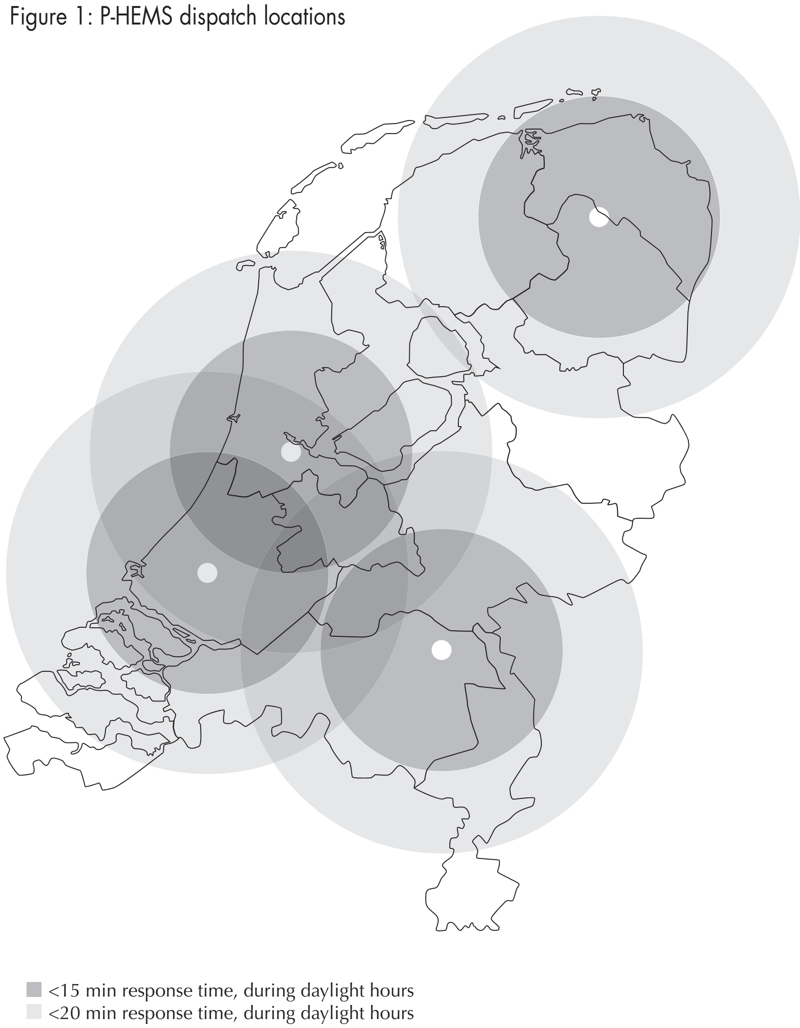
Trauma in general

Traumatic injury is a term which refers to any physical harm of sudden onset to someone's body caused by an accident. Traumatic injuries may affect everyone, regardless of gender, age, race or social economic status. These traumatic injuries can be caused by, but are not limited to, road traffic crashes, violence, falls, drowning, sports, burns and many other factors. In the earlier years of life, mortality rates are higher as a result of injury than they are of any other causes including cancer [1]. Today more than 14,000 people die each day as a result of a traumatic injury [2]. Death and damage caused by injury have an immeasurable impact on the affected person, their families and social structures. Apart from the personal tragedy, injuries are responsible for an estimated 6% of all years lived with disability [2]. Falls for instance are responsible for over 17 million disability-adjusted life years (DALY) lost on annual base [3]. The ultimate goal is of course to prevent injuries and a lot can be done to minimize the incidence of injury. For medical systems, the emphasis has been on providing high quality care, improving the organization, planning and access to trauma care systems and including prehospital-based care. Primary management of the severely injured is often done according to the Advanced Trauma Life Support (ATLS) approach, which aids emergency medical services (EMS) across the globe in a concise and systematic approach to care for a trauma patient. It helps to assess a patient's condition, as well as resuscitate and stabilize the patient [4]. Pre-hospital trauma care varies per country or even per region. However all systems aim to provide prompt provision of emergency care and swift transport of the patient from the scene of the accident to a healthcare facility [5, 6]. In the 1970's, the first civilian helicopters were used to transport traumatically injured patients to trauma centers [7, 8]. This was done based on war reports showing increased survival after shortening time to definite care by transporting war victims with helicopters to Mobile Army Surgical Hospitals (MASH) [9- 14]. Today, Helicopter Emergency Medical Services (HEMS) are widely used in most first world countries [15-24]. They are used for transporting major trauma patients from the scene of the accident to the most appropriate trauma center or primarily to rapidly transport specialized medical care to the trauma patient in addition to EMS.

The Dutch prehospital trauma system

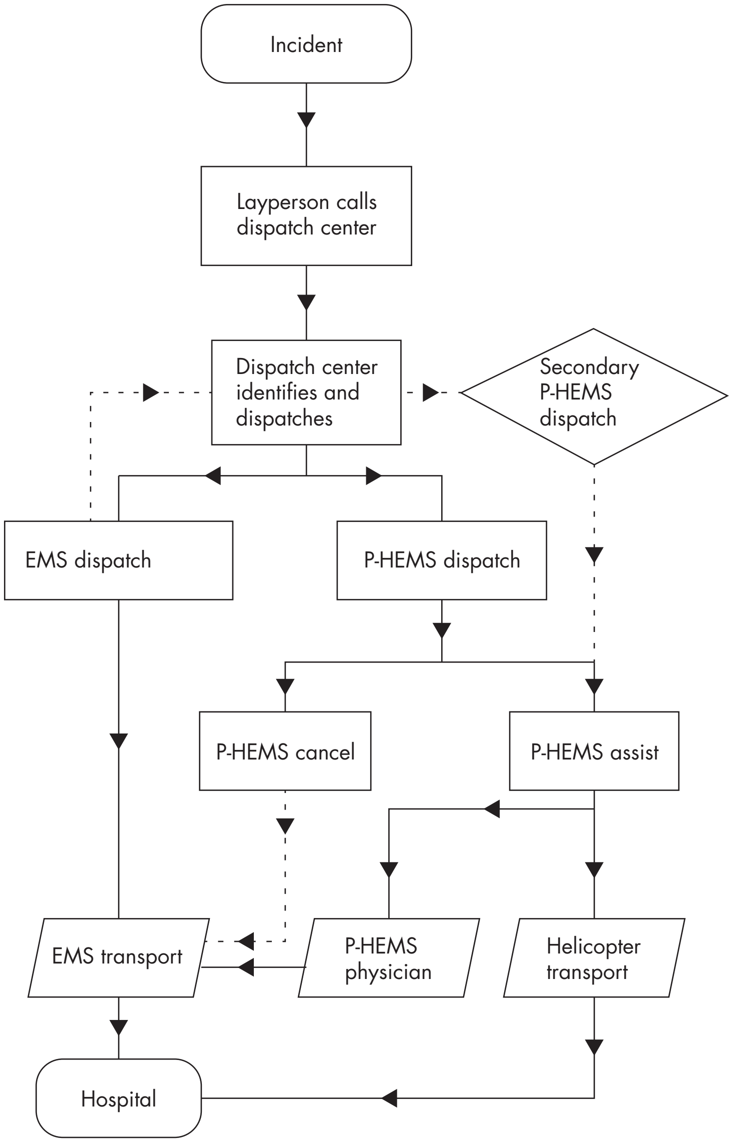
In The Netherlands EMS provide standard prehospital trauma care. All EMS care providers are highly trained and certified nurses with advanced training in either anesthesia, intensive care, cardiac care or emergency care and have additional certification in prehospital trauma life support (PTLS) [25, 26]. To improve prehospital care for the severely injured, physician-staffed Helicopter Emergency Medical Services (P-HEMS) were introduced in 1995. The first P-HEMS, known as the Lifeliner One, was a joint venture between VU University medical center in Amsterdam and the Royal Dutch Touring Club (ANWB). A P-HEMS

Figure 1: P-HEMS dispatch locations



rapidly delivers ATLS to the trauma patient in the out of hospital setting. A Dutch P-HEMS consists of either a specialized anesthesiologist or trauma surgeon and a specialized trauma nurse with at least five years of working experience in the emergency room (ER) or at the EMS. The ANWB provided the helicopter and a helicopter pilot. For the first few years, the Lifeliner One was operational only during daylight hours - since 2011, the Lifeliner One is stand-by 24/7 and airborne within 3 minutes after being dispatched [27]. Nowadays, The Netherlands is covered by four P-HEMS team (Fig 1). In 2001, the government added specialized cars to the P-HEMS fleets to ensure physician-staffed Emergency Medical Services (P-EMS) dispatch even when the helicopter is unable to fly (e.g. due to weather

Figure 2: Schedule of EMS and P-HEMS dispatch



EMS: Emergency Medical Services
P-HEMS: Physician staffed Emergency Medical Services

conditions) or when the location of the accident is not suitable for landing [27]. For clarity, we will further refer to both P-HEMS and EMS as P-HEMS. P-HEMS not only rapidly deliver advanced trauma care in the out of hospital setting, but also beyond Advanced Trauma Life Support (ATLS) guidelines [4]. Medical interventions performed are, amongst others; rapid sequence intubation, advanced pain management, the administration of inotropes, vasopressors or other medication. A P-HEMS can also perform invasive trauma surgical interventions such as a surgical airway, thoracocentesis, resuscitative thoracotomy, amputation and advanced hemorrhage control. The P-HEMS physician coordinates the treatment sequence, the logistical process, transport and is responsible for the outcome of the trauma patient [28]. The Lifeliner One is located at VU University medical center, and in 2015 it was dispatched 3018 times, of which 65% by helicopter and 35% by car. 53% percent of the dispatches were continued with 47% cancelled. 167 dispatches concerned pediatric cases. Prior to the year 2015, 92% of all dispatches were trauma related, however dispatch criteria were broadened especially in regard to pediatric, septic and cardiac dispatches, yielding a 70% trauma-related dispatch for the year 2015.

Triage and dispatch

In the event of a severe trauma, emergency operators in the dispatch center (DC) deploy the P-HEMS simultaneously with the EMS ambulance crew. This is known as the primary dispatch, and is mainly based on the initial distress call to the DC by a bystander, often a layperson. Because this information can be incomplete or incorrect, the DC handles a low activation threshold for dispatch to minimize under triage (Fig 2). Primary dispatch criteria are based on the condition of the patient, the mechanism of injury or on logistical factors. An extensive overview is seen in appendix 1. EMS often arrive on-scene first, where they evaluate the situation and report back to DC and P-HEMS with a situational report. Based on this information, a decision is made to either continue or cancel P-HEMS dispatch. When HEMS have not primarily been dispatched a secondary dispatch can be requested by the EMS crew on-scene based on their first assessment [28]. DC operators either have an EMS background or are clinically trained nurses. The DCs often use a computerized system that assists operators in the decision making process. For example, the Advanced Medical Priority Dispatch System (AMPDS) or the digital version ProQA (Professional Quality Assurance). These ensure DC operators adhere to a protocol, eliminating the factor of personal experience and knowledge from the decision making process [29, 30].

In hospital trauma management

In 1999, 10 Dutch hospitals were designated to be level 1 trauma centers, in 2008 an eleventh hospital was appointed [31]. The pre- and in-hospital triage was further developed to facilitate optimal distribution of trauma patients to the appropriate medical facilities. Organization of trauma care differs on institutional level as does the composition of trauma teams. There are downgrading systems, which allows for a reduction in trauma team staff based on an in-hospital triage tool, or upgrading-systems, which upgrades a less extensive trauma team to a more elaborate one based on in-hospital triage [32, 33]. Similarities between the different systems are that they both aim at rapid resuscitation and stabilization of the patient whilst reducing the time to diagnosis and treatment and improving survival rates. The current systems have resulted in significant over triage (e.g. unappropriated usage of recourses) in order to minimize under triage (e.g. inadequate care and treatment for the severely injured patient) and thus preventable morbidity and mortality [32, 34]. An over-triage percentage of up to 35% is justified according to the American College of Surgeons Committee on Trauma [34].

Several factors can make pre-hospital triage challenging. Firstly, primary dispatch is performed based on a phone call by a layperson, and this information is often incomplete. Secondly, the exposure of EMS to complex major trauma patients is relatively low, which could lead to a difference in interpretation of the patient's hemodynamic status and the type of care required for such a case. Moreover, two different dispatch systems are used in the Netherlands, the ProQA-system a more protocol led system and the NTS (Nederlands Triage Systeem, Dutch Triage system) which allows more liberty in interpretation by the dispatch operator. This creates differences in deployment of recourses for the same case. Furthermore, several scoring systems have been devised for the pre-hospital assessment of a patient's injuries, although there is no consensus on the usage of one method. Additionally pre-hospital settings vary widely from each other making it challenging to capture each case in a standard scoring set. Lastly, EMS sometimes feel the pressure to quickly transport a patient to the nearest hospital, spending as little time as possible in the pre-hospital setting. This sometimes creates hectic situations, which can impair triage, but even more so communication between all EMS. Proper communication is essential for shared situational awareness to aid in adequate deployment and management of all pre-hospital EMS.

Objective of this thesis

The objective of this thesis is to improve the quality of integrated trauma care for the severely injured patient. Emphasis has been on factors of influence on the quality of pre-hospital trauma care by P-HEMS. This includes the collaboration between all pre-hospital partners, early pre- and in-hospital triage and treatment for the severely injured patient.

Part 1

In Chapter 2 focus is on trying to identify the effect of time spent in the pre-hospital setting on the outcome of a trauma patient. Time is considered a critical element in the initial care for trauma patients. For instance, the 'golden hour', which is the immediate time after injury in which swift and adequate resuscitation and stabilization are perceived to be most beneficial. Current pre-hospital trauma systems are designed to shorten this time interval between accident and hospital. However, on-site advanced trauma life support delivered by either EMS or P-HEMS is associated with increased pre-hospital times, though likewise increasing survival rates. Therefore, we systematically assessed the relationship between pre-hospital time intervals and the outcome of trauma patients.

Part2

In part two the focus is on identifying problems and limitations in Dutch prehospital trauma care regarding the P-HEMS. Chapter 3 targets prehospital communication. Prehospital communication in trauma care for the severely injured is often done in hectic situations, and adequate communication is essential for all EMS to generate proper situational awareness, allowing for shared decision making and improve trauma patient outcome. This study describes the methods used for communication between DC, EMS and P-HEMS. It further assesses communication on the implementation of a new P-HEMS cancellation model on which Chapter 4 further elaborates. In Chapter 4 the prospective implementation of a new P-HEMS cancellation model is depicted. This new model was developed based on low predictability for major trauma of the current national cancel criteria. The new model aims to safely triage and cancel P-HEMS dispatches, whilst correctly identifying major trauma patients in need of care by a P-HEMS. In Chapter 5 we present the protocol of the DENIM study ('DElphi studie in Nederland naar de Inzet van het MMT', Delphi study in the Netherlands on the dispatch of the Mobile Medical Team (P-HEMS)) a Delphi-procedure on the identification of trauma patients in need of care by Physician staffed Emergency Medical services (P-HEMS) in the Netherlands. This study is essentially aimed at reaching national consensus amongst experts in the field of prehospital trauma care on the question; which acute trauma patient is in need of care by a P-HEMS? Chapters 6 and 7 present the results of the DENIM study. Chapter 7 focusses on a new method for handing over in the prehospital setting.

Part 3

In the third part of this thesis communication between all pre-hospital EMS and the receiving in hospital team is assessed and the focus has shifted from pre-hospital trauma care to in hospital trauma care. Several aspects of primary shock room triage are reviewed, such as trauma team activation, radiological examinations and surgical interventions.
The effect of the triage system, changes and the interventions on trauma patient are also reviewed. Chapter 8 evaluates the implementation of a two-tiered trauma team response system for shock room presentations of all trauma patients. An assessment was made on the pre-hospital announcement, usage of the activation criteria and the outcome of the trauma patients divided into major and minor trauma patients. This further allows us to evaluate the effectiveness and safety of the new triage model and showing the ability to identify major trauma patients. Chapter 9 shows how improvements in the trauma system, both prehospital as well as in hospital have changed trauma patient outcome. A cohort comparison study was performed to assess the differences in trauma patient characteristics, mechanism of injury, pre- and in hospital recourses used and differences in survival.

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Part 1

Prehospital trauma care for the severely injured

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Chapter 2

The influence of prehospital time on trauma patients outcome: A systematic review

ABSTRACT

Objective

Time is considered an essential determinant in the initial care of trauma patients. Salient tenet of trauma care is the 'golden hour', the immediate time after injury when resuscitation and stabilization are perceived to be most beneficial. Several prehospital strategies exist regarding time and transport of trauma patients. Literature shows little empirical knowledge on the exact influence of prehospital times on trauma patient outcome. The objective of this study was to systematically review the correlation between prehospital time intervals and the outcome of trauma patients.

Methods

A systematic review was performed in MEDLINE, Embase and the Cochrane Library from inception to May 19th, 2014. Studies reporting on prehospital time intervals for emergency medical services (EMS), outcome parameters and potential confounders for trauma patients were included. Two reviewers collected data and assessed the outcomes and risk of bias using the STROBE-tool. The primary outcome was the influence on mortality.

Results

Twenty level III-evidence articles were considered eligible for this systematic review. Results demonstrate a decrease in odds of mortality for the undifferentiated trauma patient when response-time or transfer-time are shorter. On the contrary increased on-scene time and total prehospital time are associated with increased odds of survival for this population. Nevertheless rapid transport does seem beneficial for patients suffering penetrating trauma, in particular hypotensive penetratingly injured patients and patients with a traumatic brain injury.

Conclusion

Swift transport is beneficial for patients suffering neuro trauma and the hemodynamically unstable penetratingly injured patient. For hemodynamically stable undifferentiated trauma patients, increased on-scene-time and total prehospital time does not increase odds of mortality. For undifferentiated trauma patients, focus should be on the type of care delivered prehospital and not on rapid transport.

INTRODUCTION

Trauma is one of the major causes of death worldwide; approximately five million people die each year as a result of traumatic injuries. In the USA alone, trauma is the leading cause of death for Americans under the age of 40 [1]. In 2011, road traffic injuries claimed nearly 3,500 lives each day worldwide [2]. Emergency medical systems (EMS) around the world are constantly evolving in order to reduce these numbers and provide better quality medical care. To do so, focus has often been on shortening prehospital times [3]. Historically, time is considered to be an essential determinant on the outcome of trauma patients. A fundamental tenet of trauma care is the 'golden hour', the immediate time after injury when resuscitation, stabilization and rapid transport are perceived to be most beneficial to the patient [4]. It is thought that when advanced emergency medical care is provided in this brief window of time and this time interval is kept to a minimum, mortality and morbidity of the trauma patients will be reduced [5–8]. However, not all trauma literature is in concordance on this matter [9,10]. In many emergency medical systems patients spend this extremely important time-interval in a prehospital setting, without receiving definitive care [11]. Though it seems intuitive to transport a trauma patient as fast as possible to a trauma center, especially those with a severe hemorrhage or increasing intracranial pressure, this may have adverse effects on the outcome, as some patients may be in need of specialized care before transfer [9,12]. There is discussion on the exact influence of the duration of time elapsed before reaching a trauma center on patients outcome. Many of the scientific findings concerning prehospital times derive from studies done in war settings with military systems of care [13]. Whether or not this can be extrapolated to civilian trauma care, has not fully been investigated. Different ideas exist with regard to geographical factors, the mechanism of injury (MOI) and swiftness of transfer [14]. Timely transfer is thought to be a critical predictor of outcomes for patients with acute traumatic injuries in rural and developing regions. This is also true for the penetrating injuries where the concept of 'scoop and run' is often implemented. Several studies have tried to investigate the effect of prehospital time intervals on patient outcome [15–17]. So far, no study has systematically reviewed the effect of the prehospital time intervals on outcome parameters for trauma patients. The objective of this study was to systematically examine and review the influence of different time intervals in the prehospital phase on outcome measurements for trauma patients. Our aim is to provide a thorough summary of the current relevant literature.

METHODS

This systematic review was performed according to the recommendations of the preferred reporting items for systematic reviews and meta-analysis (PRISMA statement [18]).

Searches and data sources

To identify all relevant publications, systematic searches were performed in collaboration with a medical research librarian, in the bibliographic databases PubMed, Embase.com and The Cochrane Library (via Wiley) from inception to May 19th 2014. Search terms included controlled terms from MeSH as well as free text terms in PubMed, Emtree in embase.com. We used free text terms only in The Cochrane library. Search terms expressing 'trauma patients' were used in combination with search terms comprising 'on-scene time' and 'outcome parameters'. The references of the identified articles were searched for relevant publications. The search strategy in PubMed can be found in Appendix 2. We applied a language restriction; English, German and Dutch articles were included. The search was further limited to articles with an abstract available and we only included observational studies, as our goal was to observe the normal standard of care delivered without intentionally altering care in order to test an intervention. The separate results from all searches were reconciled for duplicate articles. All searches were conducted by two investigators with prior experience in conducting a systematic review (A.H., E.J.).

Selection of studies

We included studies that reported criteria concerning pre-hospital EMS time intervals for trauma patients (1); this could mean either one of the following intervals: on-scene time or total prehospital time and when also available activation interval, response time and transfer time. Definitions of the time intervals used are portrayed in Table 1. The studies had to investigate the influence of the length of prehospital times on outcome parameters (2). Adequate information had to be provided on outcome parameters such as; length of hospital admission, length of ICU admission or mortality. Definitions of prehospital time intervals and outcome measurements had to be clarified (3). Exclusion criteria were articles with insufficient information (1), for example, very limited or only gross information on prehospital transport time intervals. Article with duplicates of previously published data (2), articles with no full-text available (3), comments (4), editorial (5), studies that did not adjust and/or report on confounders (6) or inadequate statistical analysis (7), were also excluded. The abstracts obtained by the search were independently reviewed for suitable articles by two reviewers (A.H., P.M.). If suitable the full-text versions were retrieved. Furthermore, we manually searched the reference-list of included publications and the subject indices of prominent journals to identify further suitable articles. Two investigators (A.H., P.M.) independently assessed all full-text articles to ensure that the inclusion criteria were met. Any discrepancies between the reviewers about the articles meriting inclusion were resolved by consensus after deliberation with a third investigator (G.G.).

Table 1. Definitions of prehospital time intervals.

Pre hospital time interval	Abbreviation	Definition
Activation time	AT	Time required for EMS to deploy after emergency call
Response time	RT	Includes the AT and the time to get to the scene of accident
On-scene time	OST	Time spent on scene by EMS
Transport time	TT	Time from departing scene to arrival at the hospital
Total prehospital time	TPT	Total time between emergency call and arrival at the hospital

EMS: emergency Medical Services

Data extraction and management

The following data were extracted from the studies when available: title, year of publication, location of study, study design, number of patients, MOI, age and gender of participants, prehospital time interval: activation time (AT), response time (RT), on-scene time (OST), transfer time (TT) or total prehospital time (TPT). The outcome parameters extracted when available were mortality, hospital length of stay (LOS), days of admission to the ICU and complications (as reported by the American College of Surgeons (ACS)). When an included study did not supply the necessary information the authors were contacted by e-mail to provide the additional information. Unfortunately many of the authors addressed were unable to supply us with the requested information. We attempted to perform a meta-analysis with the available and acquired data to combine results and to estimate more the true effect size. However, due to heterogeneity of the analyses used, inability to extract data from the papers and inadequate information provision, this could not be achieved.

Assessment of methodological quality and risk of bias

The methodological quality of each included paper was assessed by two independent reviewers (A.H., G.G.) using the elaborate STROBE-statement for non-randomized observational studies [19]. The level of evidence of each article was scored using the grading system for level of evidence from the Centre for Evidence-Based Medicine [20]. The levels of evidence range from one, which entails high-quality evidence up to five, which entails poor quality evidence or expert opinion. Discrepancies were thoroughly discussed and resolved by consensus.

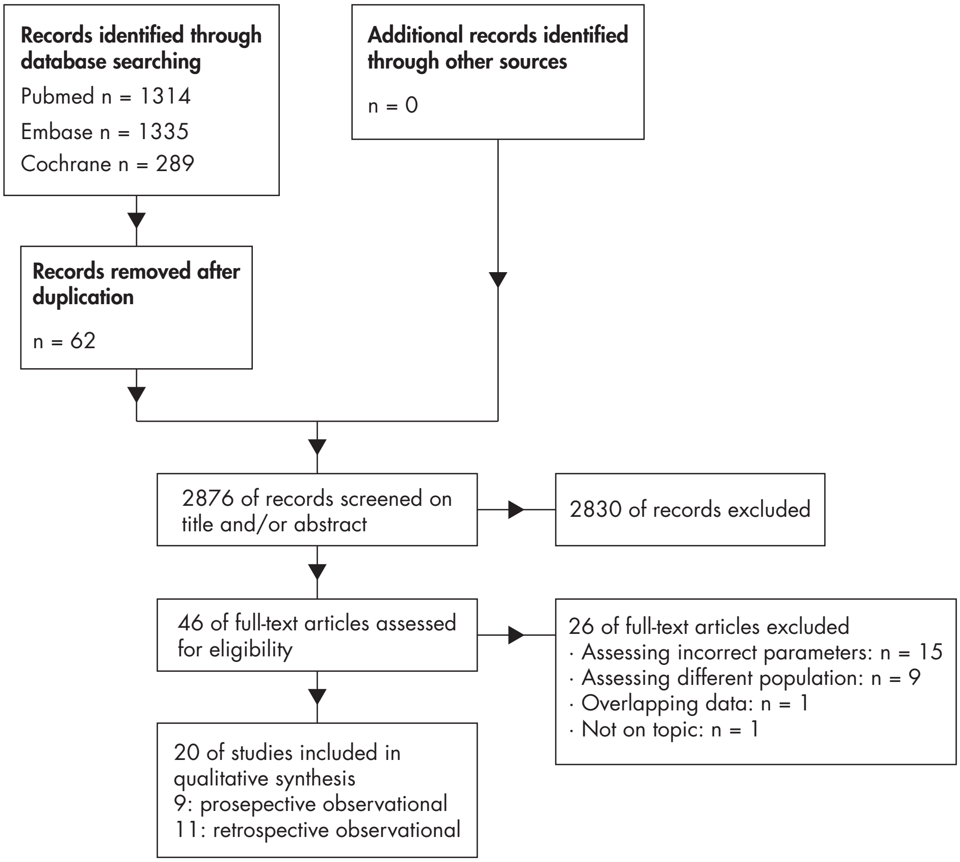
RESULTS

The search yielded a total of 2,938 potentially relevant articles. After removing duplicates of references that were selected from more than one database, 2,876 references remained. We discarded 2,830 on title or abstract because they were not relevant. The full-text articles of the remaining 46 were retrieved: 26 studies were excluded from further analysis; one due to duplicity of data, 15 were discarded due to improper or no relationship between variables of interest, one was not on topic and nine wrote on a non-trauma patient population.
The flow chart of the search and selection process is presented in Fig. 1. Finally, twenty observational studies were included in the review. Of which nine were prospective and eleven were retrospective. The overall quality of the included studies was judged ''high risk of bias'' (no or insufficient reporting on the item), ''unclear risk of bias'' (unclear manner of reporting) or ''low risk of bias'' (appropriate manner of reporting on the item). This was done for all 22 items of the STROBE instrument (Fig. 2). Eleven individual items were judged as low risk of bias for all studies. High risk of bias items often included: lack of reporting potential sources of bias and not reporting on how missing data was handled in the methods section; not reporting on reasons for non-participation at each stage of the study, failing to use a flow diagram and failing to indicate the number of participants with missing data for each variable. Two individual items were judged not applicable for all included studies. The entire list of strobe item ratings per study is available in Appendix 3. All studies were classified as level of evidence three. This entails individual case-control studies, of consecutive or non-consecutive nature; or without consistently applied reference standards. The selection of patients in all studies was by consecutively admitted trauma patients, in order to ensure appropriate representativeness and minimizing selection bias. The studies obtained data from either a government department concerned with trauma care registry, hospital trauma registries, police motor vehicle crash data or outcomes of the consortium epidemiologic out-of-hospital trauma. Table 2 presents an overview of the characteristics of included studies.

Activation time (AT)

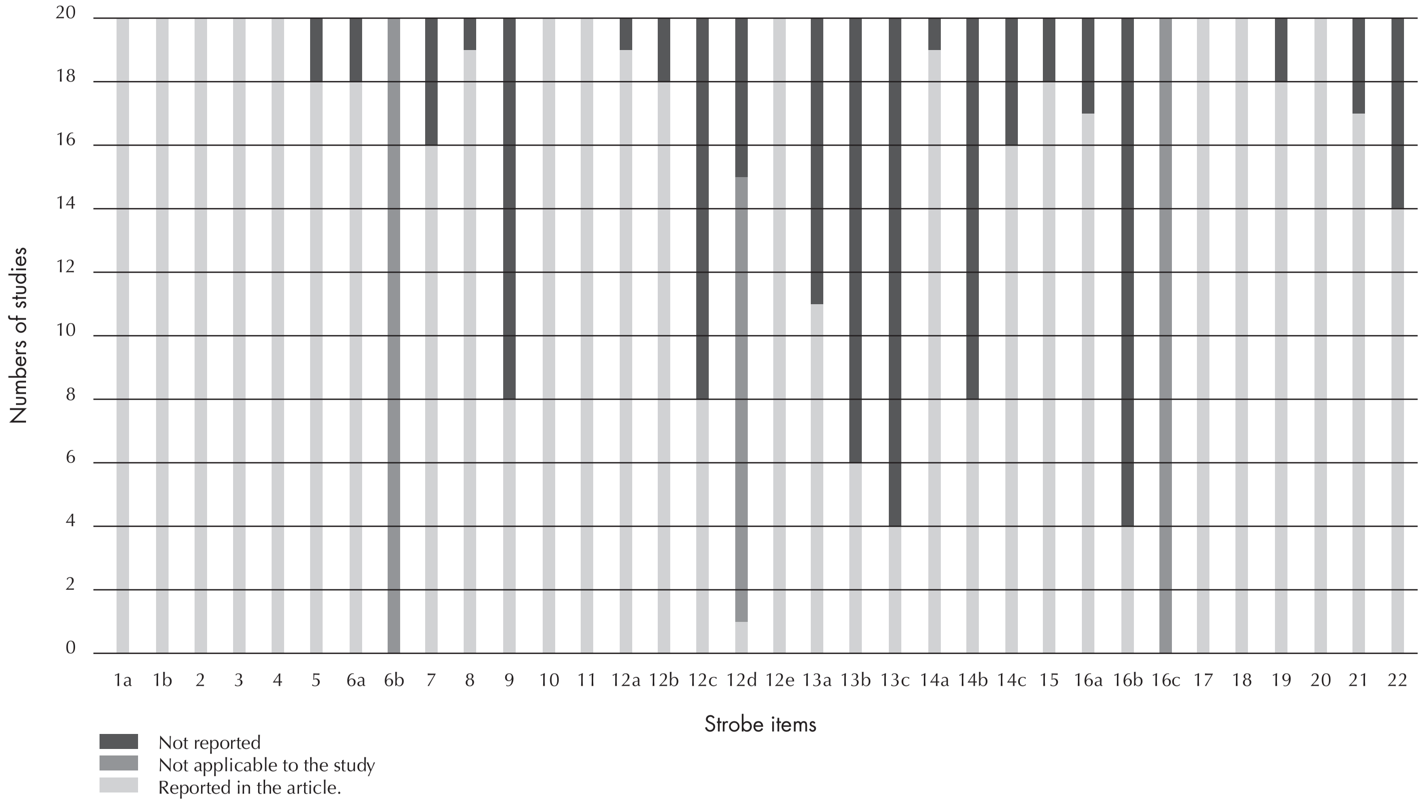
In the study by Kidher et al. [21] the authors were unable to find a statistical significant effect of AT in quintiles on mortality in severe thoracic trauma patients. Newgard et al. [22] were also unable to demonstrate independent association between mortality and activation interval in adult trauma patients.

Figure 1: Flowchart of in- and exclussions of articles in the studies



n = number of articles

Figure 2: STROBE tool for the assessment of risk and bias



Response time (RT)

Of the included studies six report on influence of the duration of RT on mortality. Three studies report on undifferentiated trauma patients [6,16,22]. Feero et al. [6] and Gonzalez et al. [16] show a prolonged RT is associated with higher mortality. Feero et al. [6] use the TRISS methodology to calculate the probability of survival (POS), this was used to calculated the unexpected survivors; those who survived despite a POS <50% and the unexpected deaths; those who died despite a calculated POS >50%. Feero et al. shows RT to be shorter for unexpected survivors versus unexpected death. Gonzalez et al. divided the included patients into urban or rural groups for analysis and report that longer RT was significantly associated with increased mortality in rural settings, though this was not seen in the urban setting. However, Newgard et al. [22] were unable to show an association between mortality and RT. Three studies report on the influence of RT in thoracic injured patients [21,23,24]. Kidher et al. [21] show no significant effect of RT on mortality. Funder et al. [23] likewise show no significant association for patients suffering penetrating trauma to the thorax, abdomen and/or neck.

On-scene time (OST)

Ten of the included studies report on influence of the time spent on-scene on mortality. Five of the studies report on undifferentiated trauma patients. Feero et al. [6] report no statistically significant difference in OST between unexpected survivors and deaths. Newgard et al. [22] show no association. Ringburg et al. [17] state that HEMS care is associated with a 9.3 min longer OST but after adjusting for confounders mortality was equal for the EMS and EMS/HEMS groups. Gonzalez et al. [16] report similar OST for survivors and nonsurvivors in an urban setting. However in the rural setting they report that OST was significantly longer for nonsurvivors. Though Petri et al. [12] report that mean OST was significantly lower among decedents, they stratify patients into groups on the basis of ISS. Four studies report on patients suffering penetrating injuries. Eachempati et al. [25], Funder et al. [23] and Honigman et al. [26] report that the OST did not differ significantly between survivors and nonsurvivors. In contrast McCoy et al. [27] show patients with penetrating injuries with an OST ≥ 20 min have a higher odds ratio of mortality versus patients with OST <10 min. OST of 10–19 min was not significantly associated with mortality. McCoy et al. [27] also report on patients suffering blunt force trauma. They were unable to show an association between OST and an increase in odds ratio of mortality. Kidher et al. [21] report on patients suffering thoracic trauma, and they report no significant differences between survivors and nonsurvivors for OST.

Transport time (TT)

Nine of the studies report on influence of TT on mortality or days of hospital admission. Five studies report on undifferentiated trauma patients. Feero et al. [6] show no significant difference between unexpected survivors versus unexpected deaths, New-gard et al. [22]

also fail to show a significant association between mortality and TT in minutes. However Gonzalez et al. [16] and Petri et al. [12] show that nonsurvivors have a significant shorter TT. McGuffie et al. [28] divided the included patients into urban or rural groups for analysis, they report no association in both rural and urban setting between mortality and TT. However they did show TT to be a significant factor when total length of hospital stay was modelled, longer TT was associated with a longer hospital stay. Three studies report on patients suffering penetrating trauma. Eachempati et al. [25] and McCoy et al. [27] show no increased odds of mortality for longer TT. However, Swaroop et al. [24] show significantly shorter TT for hypotensive patients versus normotensive patients. No correlation is made with mortality. Kidher et al. [21] report no statistically significant effect of TT on mortality for thoracic trauma. McCoy et al. [27] also report on blunt injury, they were unable to find an association between TT and mortality.

Table 2. Study characteristics of the included articles

Author country Year	**Database Study type**	**Type of trauma pt, sample size**	**Confounders**	**Outcome: correlation between time interval & outcome**
Beaz USA 2006	DOH Retrospective	Adult (ISS>15) n= 1.866	Gender, age, ISS, RTS,	↑TPT – ↑LOS (p = .001) ↑TPT – ↑Comp (p = .016)
Brooke USA 2003	RTD Retrospective	Adult n= 1.877	Age, ISS, RTS, CUPS	TPT – Mort: non sig (OR 0.987, 95% CI 0.97 to 1.00 p = .023)
Dinh AUS 2012	RTD Retrospective	Adult TBI (AIS ≥3) n= 983	Age, GCS, ISS, Hypotension, need for craniotomy	↑TPT – ↑Mort (HR 1.002, 95%CI 1.001–1.004, p = .001). Survival benefit TPT < 90min (OR 0.35, 95% CI 0.18 to 0.65 p = .001)
Eachempati USA 2002	RTD Prospective	Penetrating abdo/vasc n= 36	BD, BP, NVI, EBL	OST - Mort: non sig (p = .105) TT - Mort: non sig (p = .651)
Feero USA 1994	SIR Retrospective	Major trauma n= 848	TRISS	RT/OST/TT/TPT - sig ↓ for unexpected survivors (resp. p = .04, p = .06, p = .17, p = .02)
Funder DK 2010	RTD Retrospective	Penetrating neck/ thorax/ abdomen n= 467	Age, gender, RT, OST, TT, ISS,	RT – Mort: sig (p = .04) OST – Mort: non sig (OR 3.71, 95% CI 0.66 to 20.70 p = .14)
Gonzalez USA 2009	SIR Prospective	Crash victims n= 45.763	Urban/rural	Survivors: ↓RT (p = .0001) Survivors: ↓OST (p = .0014) Mortalities: ↓TT (urban p = .0056, rural p = .0002)
Härtl USA 2006	SIR Retrospective	TBI (CGS <9) n= 1.123	Age, pupillary status, SBP, GCS	TPT- Mort: non sig (OR 1.00, 95% CI 1.00 to 1.00 p = .25)
Honigman USA 1989	RTD Prospective	Penetrating cardiac n= 70	N= procedures, n= IV lines, EI, PASG, RTS	OST - Mort: non sig (p = .20)
Kidher UK 2012	RTD Retrospective	Thoracic n= 688	ISS, TOI	TPT > 65min OR 1.43 on Mort (95%CI = 0.52–3.92 p < .001)
McCoy USA 2013	RTD Prospective	General n= 19.167	Age, ISS, RTS, MOI	OST ≥ 20 min ↑Mort (OR 2.90, 95%CI 1.09 to 7.74)
McGuffie 2005 UK	SIR Prospective	ISS >8 n= 4.531	Age, ISS, RTS, MOI, TOI, type of care, geographic	RT/ OST/ TT – Mort / LOS: non sig

Author country Year	Database Study type	Type of trauma pt, sample size	Confounders	Outcome: correlation between time interval & outcome
Newgard USA 2010	NTD Prospective	Adult n= 3.656	Age, RTS, ALS/ BLS, TOI, GCS, BP, HR, EI	No sig association between time and mortality for AT(OR 1, 95% CI 0.95 to 1.05), RT(OR 1, 95% CI 0.97 to 1.04), OST(OR 1, 95% CI 0.99 to 1.01), TT (OR 1, 95% CI 0.98 to 1.01), TPT(OR 1, 95% CI 0.99 to 1.01)
Osterwalder CH 2002	SIR Prospective	Blunt n= 254	ASCOT, MOI, OSP, EI	Mort higher TPT < 60min compared with TPT > 60min (OR 8, 95% CI 1.7 to 38.5)
Pepe USA 1987	RTD Prospective	Hypovolemic penetrating n= 498	TS	Survival did not change significantly with increasing TPT
Petri USA 1995	RTD Retrospective	General n= 5.215	ISS, time variables	OST, TT and TPT sig shorter among nonsurvivors (all p-values < .001)
Ringburg NL 2007	RTD Prospective	General n= 1.457	Age, RTS, ISS, day-time, MOI	No higher chance of mort with increasing mort (OR 1, 95% CI 0.8 to 1.3 p = .89)
Ryb USA 2012	NTD Retrospective	Adult n= 192.422	EMS/HEMS, RTS, ISS	Survival higher for TPT > 60 min (OR 1.68, 95% CI 1.52 to 1.87).
Swaroop USA 2013	SIR Retrospective	Penetrating thoracic n= 908	Age, race, ISS, BP	↑TT - ↑mort hypotensive pt 0-15 min (OR 3.87, 95% CI 0.1.45-10.28), 16-30min (OR 5.90, 95% CI 4.42-7.88) 31-45 min (OR 8.99, 95% CI 5.35-15.11), 46-60min (OR 13.00 95% CI 1.98-85.46). For normotensive pt showed ↓mort with ↑TT (OR 0.93, 95% CI 0.83-0.99, p < .001).
Tien CA 2011	RTD Retrospective	ASDH n= 149	Age, gender, GCS, OSP, ISS, SAH, ICH,	Sign association TPT – mort (OR 1.03, 95% CI 1.004-1.05, p =.024)

DOH: department Of Health, n= number, RTS: revised trauma score, TPT: total prehospital time, LOS: length of stay, Comp: complication, RTD: regional trauma database, CUPS: critical/unstable/potentially unstable/ stable-tool, Mort: mortality, sig: significant, TBI: traumatic brain injury, AIS: abbreviated injury scale, GCS: Glasgow coma scale, BD: base deficit, BP: blood pressure, NVI: non vascular injuries, EBL: estimated blood loss, OST: on-scene time, TT: transport time, SIR: state injury registry, TRISS: trauma and injury severity score, RT: response time, SBP: systolic blood pressure, EI: endotracheal intubation, PASG pneumatic anti-shock garments, TOI: time of incident, MOI: mechanism of injury, NTD: national trauma database, ALS: advanced life support, BLS: basic life support, HR: heart rate, ASCOT: a severity characterization of trauma, OSP: on-scene physician, TS: trauma score, (H)EMS: (Helicopter) Emergency medical services, ASDH: acute traumatic subdural hematoma, SAH: Subarachnoid hemorrhage, ICH: Intracerebral hemorrhage

Total prehospital time (TPT)

Sixteen of the included studies report on the effect of TPT on mortality. Six studies report on undifferentiated trauma patients. Beaz et al. [29] uses a division between young patients, below 65 years of age, and elderly patients, equal or above the age of 65. They report that TPT did not correlate significantly with mortality, not for young patients and not for elderly. Newgard et al. [22] also fail to show an association for increasing TPT with mortality using multivariable logistic regression, even when assessed as quintiles or dichotomized (above or below 60 min). Ryb et al. [30] report that the odds of survival were slightly higher for TPT longer than 60 min. Same as the results found by Brooke et al.[31], however for their analysis they use a division based on CUPS-status and find that survivors have a significantly longer mean TPT than nonsurvivors. Though multiple predictors' logistic regression fails to show TPT as significant predictor of mortality, Petri et al.[12] also report that mean TPT was significantly lower among decedents than survivors. This contradicts Feero et al. [4] who report that TPT was significantly shorter for unexpected survivors than for unexpected death. Three studies report on patients suffering penetrating trauma. Swaroop et al. [24] report an increased OR of death with increasing TPT for hypotensive patients with penetrating thoracic injuries. Conversely the normotensive patients exhibited decreased mortality with longer TPT. However, Pepe et al. [9] show that survival did not change significantly with increasing TPT, they use the TRISS methodology to calculate the POS. McCoy et al. [27] also found that longer TPT is not associated with increased mortality. McCoy et al. [27] also report on patients suffering blunt force trauma. Here they also report no association between TPT and mortality. Osterwalder et al. [32] likewise analyzes blunt force trauma patients. They compare 30-day mortality with predicted mortality, based on a severity characterization of trauma (ASCOT) score [33] and finds 30-day mortality was higher in the group with a TPT <60 min compared with TPT >60 min. Kidher et al. [21] divided their cohort of thoracic injured patients in two groups; those with TPT above 65 min and those with TPT below 65 min. They show increased odds of mortality for the group with a TPT above 65 min. Three studies report on patients who suffered TBI. Tien et al. [34] show a nonsignificant trend using multivariate logistic regression analysis, suggesting that patients who arrived within the 'golden hour' had a lower mortality than those outside of the 'golden hour'. Dinh et al. [15] report a rise in mortality with increasing TPT. They fail to show an association between mortality and the 'golden hour' or arrival <30 min. They report survival benefit for patients arriving <90 min. Härtl et al. [35] find TPT not to be related to 2-week mortality in severe TBI patients.

LIMITATIONS

It is difficult to solely address the effect of time spent in a prehospital setting on trauma patient outcome because several factors are of influence. This is reflected in the heterogeneity of the included studies. For one, patients are divided into various categories for analyses and use different types of trauma score to allocate patients. Secondly, there are dissimilarities in included trauma mechanisms. Included subgroups are patients with penetrating injuries, blunt force trauma, TBI patients or undifferentiated trauma patients which include all pre mentioned categories. Furthermore, geographic and logistic factors have an apparent influence on time spent prehospital, one could imagine these factors to differ for each country or trauma system. An American study [36] shows that increased EMS RT and OST as well as increased distance to the scene were contributing factors to increased mortality in rural crashes. Correspondingly another factor to consider is the type of care delivered prehospital. One could imaging trauma patient outcome is different when receiving A(T)LS versus B(T)LS. Assistance of a physician or advanced critical care paramedics may lead to improved survival rates but prolong prehospital times. Härtl et al. [35] found no significant difference in mortality comparing ALS versus BLS. They also did not find a difference between air- or ground transport. Ringburg et al. and Ryb et al. [17,30] likewise assessed if transport mode, HEMS or EMS, was of influence on prehospital time of mortality. Furthermore one could hypothesize that due to changing therapies and treatments over time (for example: rapid sequence intubation, widespread access to helicopters), the older included studies report on different approaches than the newer. This may impact prehospital time intervals as well as outcome. The studies included are level III evidence [20] and thus are subject to various limitations: (i) of the included studies several were retrospective studies and are prone to selection bias and misclassification. (ii) All of the presented studies are without a control group. (iii) Two studies have limited number of patients included [25,26]. (iv) There is lack of uniformity in definitions on intervals used, type of analysis and definition of outcome. The usage of in hospital mortality as outcome parameter in some studies may have led to under reporting of mortalities. We acknowledge these limitations; consequently the findings in this review should be regarded with caution. For future research we recommend using prehospital intervals as suggested by Carr et al. [37] in a meta-analysis of prehospital care time, in which they purpose a standardized evaluation of prehospital times. Furthermore we recommend usage of 30-day-mortality. This seems the most reliable outcome parameter, because it includes the majority of surgery-related deaths and is not subject to discharge procedures [38]. However, because of the retrospective nature of many of the included studies this was not feasible.

DISCUSSION

Trauma patient outcome and the relationship with prehospital time intervals are of interest to investigate. Historically, emphasis has been on time and many of the changes in trauma care are based on the basis tenet that shorter prehospital times are better for the trauma patient, though little is empirically known on this matter. Carr et al. [37] performed a meta-analysis on prehospital care times. They provide an average duration for each time interval but do not correlate length of the interval with outcome measurements of the trauma patient. To the best of our knowledge, this is the first systematic research addressing this relationship. When reviewing the impact of RT, it seems that a shorter RT has a positive influence on mortality for undifferentiated trauma patients. This could be explained by timely medical assistance. However Weiss et al. [39], who specifically examined response time influence in trauma patients, found no correlation. When looking at OST, this is a time interval that is of special interest since this is the prehospital time interval depending on the performance of the prehospital caregiver and therefore the interval one can best influence. However, for undifferentiated trauma patients, four out of five included studies showed no influence of time spent at the scene of the accident on mortality [6,16,17,22]. Only Petri et al. [12] report that mean OST was significantly lower among decedent. When assessing the OST for patients suffering penetrating or blunt trauma, included studies showed no correlation. McCoy et al. [27] showed a positive effect of shorter OST in patients suffering penetrating trauma. This could be explained by the fact that treatment of exsanguination often requires radiological imaging and surgical interventions due to the anatomical complexity and non-compressible nature of the large vessels. Gonzalez et al. [16], Petri et al. [12] and McGuffie et al. [28] showed TT to be a significant factor of influence on mortality as well as on length of hospital stay in undifferentiated trauma patients. This could be due to expectations leading to more effective care sooner. For patients suffering penetrating or blunt force trauma no association between TT and survival could be found. Looking at TPT in trauma patients Ryb et al., Petri et al. and Lerner et al. [12,30,31] show that the odds of survival were slightly higher for longer TPT. When looking at TPT in patients suffering penetrating trauma two studies fail to show a significant change in survival with increasing TPT. However, Swaroop et al. [24] report an increased risk of death in hypotensive patients with increasing TPT and a decreased risk of mortality for normotensive patients with increasing TPT. When reviewing blunt force trauma patients one out of two studies report no association. Nevertheless, Osterwalder et al. [32] found mortality was higher with a shorter TPT. For TBI patients increased TPT seems to be related with an increase in mortality. This could be explained due to the fact that this group of patients is often in need of emergency neurosurgical interventions, such as craniotomy, which cannot be performed in the prehospital setting. When further examined expressions such as 'golden hour' three of the included studies report on this matter. Dinh et al. [15] report there was no survival benefit observed for TBI patients arriving within 60 min of injury. Tien et al. [34] likewise report on TBI patients and show a strong trend suggesting that patients arriving within 60 min of injury have a decreased mortality. Osterwalder et al. [32] report no difference in mortality between patients arriving within 1 h or after 1 h. This is in concordance with some of the literature found [4,5,7,8,10]. Though we are under the impression time is best to be analyzed as a continuous variable or at best grouped in intervals. Since the cut-off is relative arbitrary and information is lost when continuous data are transformed to dichotomous data [40]. Four of the included studies use time clustered in various categories when not considered a continuous variable [9,15,27,34]. Reviewing treatment modalities such as scoop-and-run and stay-and-treat strategies, Ringburg et al. [17] report an unsurprising higher OST for the stay-and-treat group due to factors concerning helicopter emergency medical services (HEMS) care. Longer OST in stay-and-treat does not improve outcome but return the mortality rate to that of the scoop-and-run group. However, because no increased mortality could be demonstrated there is no reason to transport sooner than current protocol in the stay-and-treat group. This demonstrates the idea that interventions performed on-scene and their duration are of great influence on the outcome of a trauma patient [41].

CONCLUSION

For undifferentiated trauma patients a shorter RT and TT may have a positive influence on mortality. However, it seems that a longer OST may increase odds of survival. The same trend is seen in TPT which is probably due to the relatively large share of OST in total TPT. This increased odds of survival with longer OST is presumably related to the comprehensive care that is delivered prehospitally, implying that for the future, the emphasis should not be on getting a patient to the hospital as fast as possible but making sure the patients receive proper prehospital care first. However, swiftness of transport is beneficial for TBI patients and patients suffering penetrating trauma, especially those who are hypotensive. The relatively low level of evidence of the included studies highlights the need for more, well designed studies to be able to fully assess the risk of time spent prehospitally on trauma patient outcome.

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Part 2

Prehospital physician staffed helicopter emergency medical services care

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Chapter 3

Limitations in prehospital communication between trauma helicopter, ambulance services and dispatch centers

ABSTRACT

Background

Prehospital communication between Emergency Medical Services (EMS) is done in hectic situations. Proper communication between all medical personal is required to enhance collaboration, to provide the best care and enable shared situational awareness.

Objective

The objective of this paper was to give insight in current Dutch prehospital emergency care communication between all EMS and evaluate the usage of a new Physician staffed Helicopter Emergency medical Services (P-HEMS) cancellation model.

Methods

Trauma related P-HEMS dispatches between November 1st 2014 and May 31st 2015 for the Lifeliner One were included, a random sample of 100 dispatches was generated. Tape recordings on all verbal prehospital communication between the dispatch center, EMS and P-HEMS were transcribed and analyzed. Qualitative content analysis was performed, using open coding to code key messages.

Results

92 tape-recording were analyzed. Most frequent reason for P-HEMS dispatch was suspicion of brain injury (24%). The cancellation model was followed in 66%, overruled in 9%, not applicable in 25%. Main reason for not adhering to the model was hemodynamic stability. In 5% of P-HEMS dispatches a complete ABCD-methodology was used for handover, in 9% a complete Situation-Background-Assessment-Recommendation technique, in 2% a complete Mechanism-Injuries-Signs -Treatment method was used. The other handovers were incomplete.

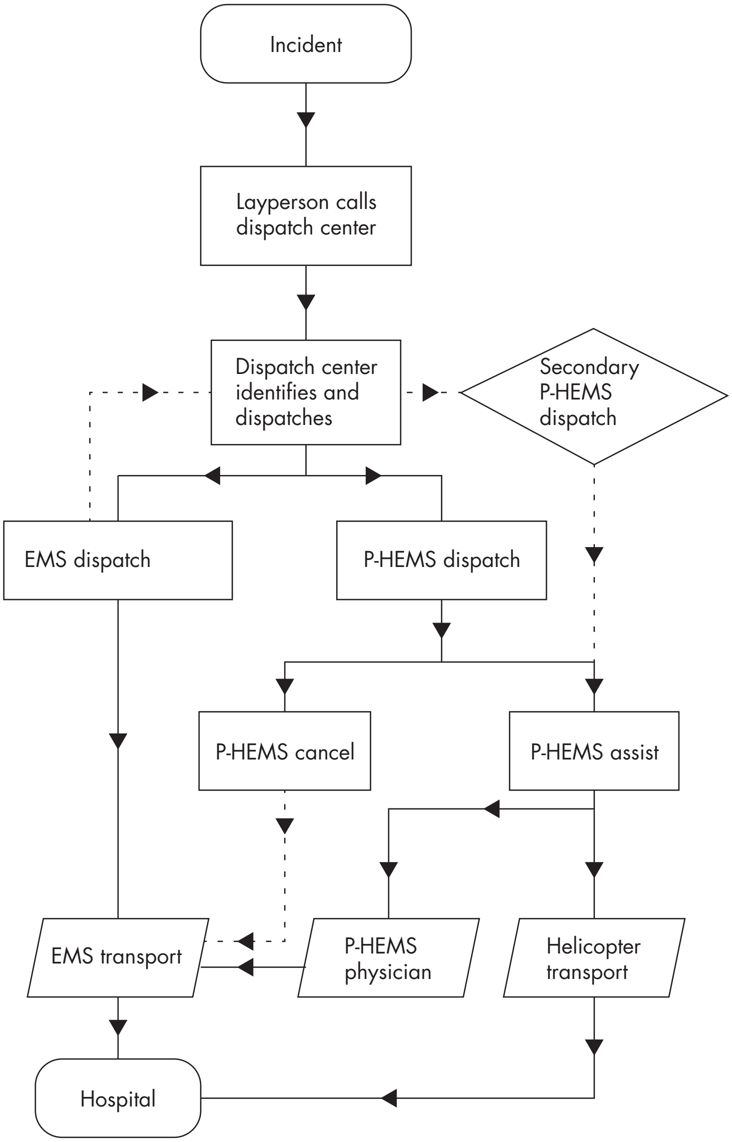
Conclusions

Prehospital handover between EMS on-scene and P-HEMS often entails insufficient information. The cancellation model for P-HEMS is frequently used and promotes adequate information transfer. To increase joined decision-making more patient and situational information needs to be handed over. Standardization of prehospital trauma handovers will facilitate this and improve trauma patient's outcome.

INTRODUCTION

In the Netherlands prehospital trauma care is provided by emergency medical services (EMS). Since 1995 this care is extended with the advance medical care of the Physicians staffed Helicopter Emergency Medical Services (P-HEMS). For patients suffering major trauma P-HEMS provide comprehensive prehospital care including airway management, administration of specific medication and trauma surgical interventions. The Netherland is divided in four regions covered by its own P-HEMS, the so called Lifeliners. The LifeLiner One (LL1)P-HEMS covers the Trauma Region North-West North (TRNWN)[1]. The LL1 is dispatched approximately 1.200 times each year, of which almost 92% are trauma-related dispatches. Of these dispatches approximately 69% is done by helicopter and the remaining 31% by car[2]. In the Netherlands, P-HEMS dispatch is mainly based on the initial distress call to the EMS dispatch center (DC) by a bystander, often a layperson. When a distress call meets certain criteria the P-HEMS are dispatched simultaneously to EMS (primary dispatch). EMS often arrive on-scene first, after evaluation EMS report back to DC and P-HEMS with a situational report. Based on this information a joined decision is made to either continue or cancel P-HEMS dispatch. When P-HEMS have not primarily been dispatched a secondary dispatch can be requested by the EMS crew on-scene based on their first assessment[2]. Dispatchers are clinically trained nurses or have an EMS background. The DC's use a computerized system that assist dispatchers in the decision making process what type of EMS to deploy. The system used is the Advanced Medical Priority Dispatch System (AMPDS) or the digital version ProQA (Professional Quality Assurance). These make sure every dispatchers adheres to a protocol, eliminating the factor of personal experience and knowledge from the decision making process[3, 4]. The EMS and P-HEMS deployment sequence is displayed in Figure 1. Several types of EMS can be dispatch on the same time. Prehospital communication between all these EMS is often done in hectic and unpredictable situations while taking care of critically ill patients. These situations require quick actions often with uncertainties on the patients' medical condition, time or resources [5]. Dialogue on all the medical and practical support goes via a "narrow" interactive communication channel, a C2000 radiotelephone, as part of the digital communication network which leverages mobile broadband connectivity to expedite prehospital healthcare providers [6]. In order for the P-HEMS to be able to communicate with EMS, they need to be patched into the conversation by the DC [7]. An important part of the DC's work is the co-ordination and sharing of information with other authorities involved in the dispatch, this co-operation enables shared situational awareness (SSA) [8]. A recent review of factors that hindered the prehospital trauma care organization in realizing satisfactory SSA showed amongst others; information gaps, lack of smooth communication and when no standardized common operational communication tool is used to negatively influence SSA [9]. They likewise report that when EMS personnel focuses solely on their individual tasks this negatively affects information transmission and leads to a hiatus incident information flow. In November 2014 the LL1 started the validation of a new cancellation criteria model for P-HEMS (Figure 2), based on an earlier performed study in our region [10]. Whilst in flight the P-HEMS physician will follow the cancellation flowchart by usage of the information handed to him or her by EMS crew and/or DC. Based on this information a decision will be made to either continue or to cancel the P-HEMS dispatch. The Dutch team configuration with both paramedics and physicians on the P-HEMS is one used in many different countries across the globe, amongst others the USA, the UK, Australia, German, France and Japan [11-13]. Though little has been published on the content and type of critical information that is needed to manage a dispatch with both EMS and P-HEMS especially in the Dutch setting. The aim of this study was to investigate how the new P-HEMS cancellation model was used in prehospital communication. We intended to review the flow of information, validate the data that is reported in the P-HEMS-database, to verify if and how the cancellation model was reported on and followed or not followed, the rationale behind model deviation and what parameters of the model were mentioned. Furthermore we aimed to evaluate if standardized common operational communication tools were used, such as Mechanism Injuries Signs and Treatment (MIST), or Situation Background Assessment Recommendation (SBAR), Airway Breathing Circulation Disability Exposure (ABCDE). We further more evaluated if there we information gaps and what factors are of influence on prehospital communication.

Figure 1: Schedule of EMS and P-HEMS dispatch



EMS: Emergency Medical Services
P-HEMS: Physician staffed Emergency Medical Services

METHODS

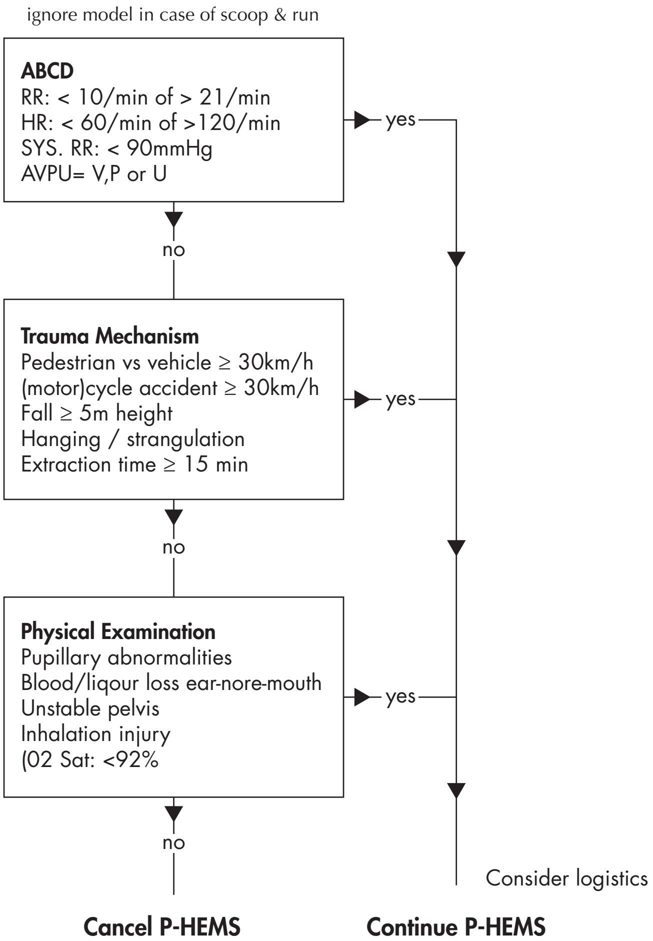
Design

A qualitative descriptive approach was chosen in order to complement the lack of data on reporting and communicating in the prehospital trauma setting between EMS and P-HEMS. All trauma related P-HEMS dispatches within the study period, November 1st 2014 until May 31st 2015, of the cancellation-study were included, of which a random sample of one hundred cases was drawn using an internet based research randomizing tool. Tape recordings of the entire prehospital communication between DC, EMS and P-HEMS were collected and transcribed verbatim for every dispatch. Data were analyzed using qualitative content analysis [14]. Two researchers (A.H and G.G) transcribed the recordings individually, a third researcher (F.B.) reviewed the differences for each transcript. Each transcript was reviewed using open coding to code the key messages. Information on whether the cancellation model was followed, parameters of the cancellation model, rationale for model deviation, which communication format (e.g. SBAR, MIST) was used and if recording matched the P-HEMS database was reviewed. The statistical data analysis was performed using SPSS 21.0. Statistical Analysis program (SPSS Inc., Chicago, IL). All three modes for outcome of adherence to the model were compared to the mode of reporting using the X^2 test. The mode of reporting was analyzed as a dichotomous variable, as well as P values were two-tailed and at a level of significance of 0.05. This study was approved by the Medical Ethics Committee.

Inclusion and exclusion criteria

All trauma related P-HEMS dispatches were included consecutively between November 1st 2014 and May 31st 2015. Dispatches for non-trauma, outside of the TRNWN and all dispatches for children below the age of 18 were excluded, leaving 274 for inclusion. Of the remaining dispatches a random sample of 100 was chosen using a computerized research randomizer. If the recorded tape was not found or if the quality of sounds was inadequate, the dispatch was likewise excluded.

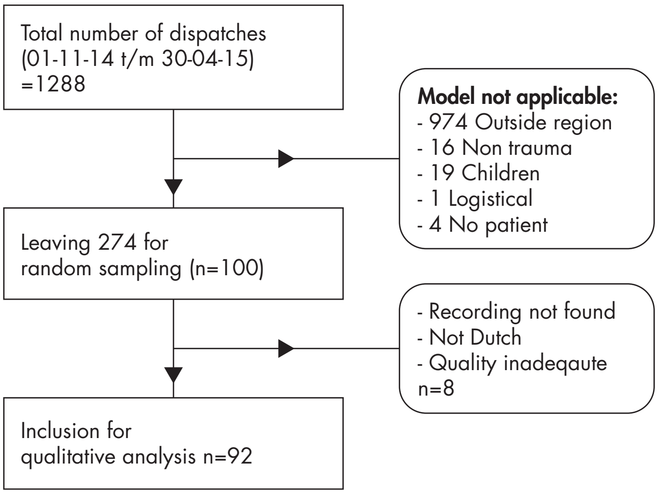
Figure 2: P-HEMS Cancellation model



RESULTS

In total 92 dispatches were included. The flow of in- and exclusion of tape recordings in this study is shown in Figure 3.

Figure 3: Flow of in- and exclusion

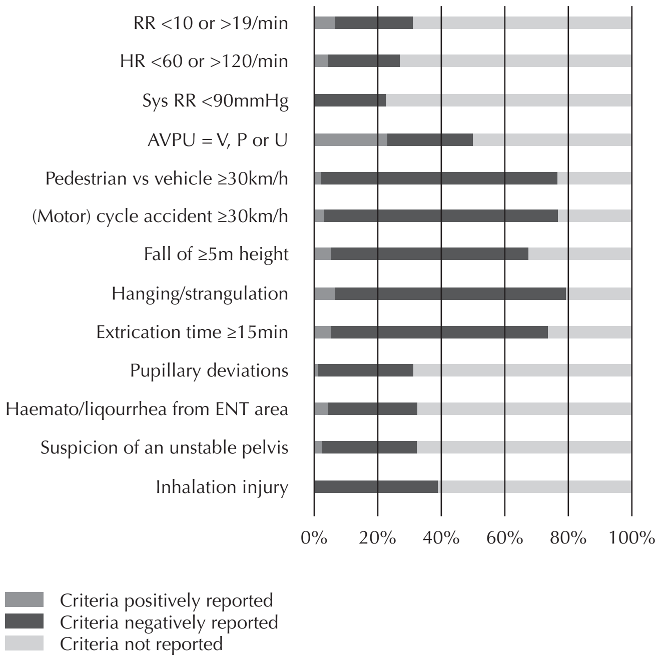


n: number

Reason for dispatch

A common reason for dispatch was the neurological status of the patient, either reported as traumatic brain injury (22 cases) or neurological abnormalities (two cases). Furthermore falls were a common mechanism of trauma. In 14 cases a fall was reported, in eleven cases it concerned a fall of height. In nine cases, attempted suicide by hanging was the reason for dispatch. Nine cases accounted for submerged vehicles, in four cases a person in the water. On three occasions a traumatic resuscitation was reason for dispatch, twice for penetrating trauma, and seven times the P-HEMS were dispatched for a one-sided accident. On three occasions they were dispatched for an incident involving a large vehicle, and the remaining six were for other reasons.

Figure 4: Reporting the parameters of the cancellation model



RR: Riva-Rocci, acronym for bloodpressure
HR: Heart rate
AVPU: acronym for Alert, Verbal, Pain and Unresponsive
ENT: Ear, Nose and Throat

Mission completion

In 37 cases the dispatch was continued, of which two a rendezvous was arranged between EMS and P-HEMS. In 55 cases the P-HEMS were cancelled. The cancellation model was followed in 61 cases, overruled in eight cases and not applicable or not indicated in 23 cases. The reason for not adhering to the model was that the patient was hemodynamically stable in seven cases and for one case it was only mentioned that the general practitioner thought P-HEMS dispatch was no longer of need. Reporting of the different parameters of the cancellation model are shown in Figure 4. Often the mechanism of trauma is reported by the layperson and therefore handed over frequently. Patient’s vital parameters were more likely to be handed over than injuries a patient sustained. The most reported vital parameter was the neurological status using the AVPU scale (acronym from “alert, voice, pain, unresponsive”). Systolic blood pressure below 90mmHg and inhalation injury were not mentioned in this cohort. However many of the model parameters were not specifically mentioned in the handover and therefore we labelled them as not reported.

Mode of reporting

In five cases a complete ABCD-methodology [15] was used, example:
EMS: "The patient's airway is clear and the breathing sounds are normal. Patient has a sinus tachycardia and a blood pressure of 120 over 70. He is responding coherently, however he does seem intoxicated with alcohol"
In 21 cases an incomplete ABCD-methodology was reported, example:
EMS: "Patient has snoring breathing sounds and is unresponsive"
In thirteen cases "ABCD-stable" was reported.
In two cases the MIST (Mechanism, Injuries, Signs and Treatment) [16] method was used, in three cases an incomplete MIST handover was done, example:
EMS: "Male patient, 64years old, fell from the top of the stairs, restless, GCS 3 to 6, after administration of midazolam (Dormicum)"
The SBAR (i.e., Situation, Background, Assessment, Recommendation) [17] communication technique was used in eight cases, example:
EMS: "27 year old motorcyclist hit by truck, no relevant medical history, apparent bilateral femoral fractures and a possible lower leg fracture on the right side, requesting P-HEMS to continue their dispatch"
Incomplete SBAR handover was done in seven cases, example:
EMS: "Attempted suicide by hanging, Now ABCD stable after oxygen therapy, no other apparent injuries"
In nine cases was reported that the patient was deceased. In three cases it was reported that there were no victims on-scene, in one case there was no communication prior to P-HEMS landing. In five cases the handover entailed merely the phrasing "P-HEMS should continue their dispatch" and in nine cases the P-HEMS were cancelled using only the phrase "P-HEMS can be cancelled". In four cases the mode of reporting was not according to one of the before mentioned methods. There was no correlation between the mode of reporting and the mission completion.

P-HEMS database

For almost all dispatches (90 cases) the information reported in the P-HEMS database matched the information on the tape recordings. For two dispatches it was not indicated in the database if the cancellation model was followed. However the verbal information handed over on the tape recording allowed us to deduce if the model was followed or not.

DISCUSSION

This study shows that the new cancellation model introduced in our prehospital system, was frequently followed. Though in eight cases the model was overruled, mostly because EMS personnel considered the patient to be hemodynamically stable and therefore did not see the additive value of P-HEMS assistance. However, a study by Giannakopoulos et al. shows that patients who are hemodynamically stable but for other reasons do adhere to the model are those that could benefit from P-HEMS care [10]. Research on the effects in over- and under-triage after implementing the cancellation model, will need to prove this and is currently being performed. Of all cases, 25% of the dispatches were excluded from this research. This was either because the dispatch was outside of the geographical research area or because it concerned a non-traumatic dispatch or a child. However in 66% of all dispatches the model was followed and reported on adequately in the P-HEMS database. Therefore the model can be operational. When reviewing which parameters of the model are reported on in the handover, most frequently the neurological status of the patient is mentioned. This could be done either in the form of AVPU, GCS or in a descriptive manner. It seems that the neurological status of the patient is thought to be one of the main reasons to continue P-HEMS dispatch, followed by breathing frequency that was outside the normal range. For the mechanisms of injury fall of height, hanging and a prolonged extrication time were most frequently reported. Especially falls of great height often required P-HEMS assistance. One of the main results of this study is that frequently the information handed over is not complete. Currently EMS on scene are responsible for a direct and clear situational report, including mechanism of injury, patient condition, location and time [18]. Based on this information, the P-HEMS physician is responsible to ensure him- or herself if continuation of P-HEMS dispatch is necessary or if the mission should be aborted [19]. The handover is essential for the quality and continuity of care. Differences in levels of skills or training of prehospital personnel should not be of influence, a structured communication format can add to this [20]. Furthermore the handover is also a method to transfer legal responsibility from one caregiver to another. However in merely 16% of all handovers a complete situation report was done. This concerned either a complete ABCD- (five cases), SBAR- (eight cases) or MIST methodology (2 cases). Moreover in 84% of all dispatches the P-HEMS physician needed to make a decision to cancel or continue the P-HEMS dispatch based on very little information. Solely ABCD-stable or an incomplete ABCD-methodology was frequently used (34 cases). A Dutch national survey amongst prehospital EMS personal shows that 76% of all respondents think that simply reporting “ABCD-stable” is insufficient to make an educated decision [personal communication]. Furthermore this study shows that 91% of all respondents are under the impression that a new and structured mode of handover could be beneficiary to structure prehospital handovers and ensure informed decision making. These lessons can be adopted in other prehospital trauma systems using the same prehospital trauma team compositions, such as some states in the USA, the UK, Australia and also Japan. An adequate handover is essential to make sure the flow of information is uniform, making it easier to evaluate, increase transparency, give more clarity and decrease communication time [21, 22]. Factors that influence prehospital trauma care via communication are amongst others the quality of the sounds. The sometimes poor quality of the transferred message via C2000 has a negative impact on communication. Often sentences need to be repeated, loss of information is accepted or EMS might even switch to the usage of cell phones. Frequently the P-HEMS do not hear the situational report of the EMS and are then informed with secondary information handed to them by the DC operator. One could imagine another interpreter in chain of communication to distort the information flow [23], thus making it less likely for the P-HEMS to receive the proper situational report. One could opt that improvement of technological infrastructure would be beneficial for the prehospital communication. However that is outside the scoop of this study as it requires a lot of legislation, financial and regulatory efforts. Another factor of influence is time, EMS tend to want to cancel the P-HEMS as quickly as possible, because they do not want to occupy valuable P-HEMS time with a dispatch not requiring P-HEMS assistance and therefore making the P-HEMS not available for other dispatches. This hastily way of communication may lead to a reduced quality of content of the message or even a hastily assessment of the patient. These factors highlight the need for usage of a structured and well defined communication model.

LIMITATIONS

One of the limitations of this study is the retrospective nature and the sometimes poor quality of the recorded conversations. Furthermore this study focuses on trauma patients. The outcome of this study can probably also be extrapolated to all non-trauma cases requiring P-HEMS, since all urgent situations require an efficient and adequate information transfer to give a good situational report. Another limitation is the usage of a qualitative research method. In qualitative research, findings do not necessarily portray the opinions or acts of a large population of individuals. Quantitative concepts of generalization are not applicable to qualitative research, meaning that qualitative results are tentative. However they can give us an indication as to how these groups tend to function. Furthermore the Dutch mode of dispatch is somewhat unique, however the Dutch system is evolving and dispatch centers have started working with the Advanced Medical Priority Dispatch System (AMPDS) system in June 2010 with is used in 38 other countries [24], making it generally applicable. Therefore this exploratory study should be interpreted as a starting point for further empirical investigations.

CONCLUSION

Prehospital communication between EMS on-scene and P-HEMS often entails little descriptive information. The cancellation model for P-HEMS introduced in our prehospital system is frequently used and promotes adequate information transfer. To increase joined decision-making more patient and situational information needs to be transferred. Standardization of prehospital trauma handovers will facilitate this in order to increase quality of care and improve patient's outcome.

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Submitted

Chapter 4

Prospective validation of an evidence based P-HEMS cancellation model in the Netherlands

ABSTRACT

Introduction

A previous study showed high cancellation rates and low predictability for Physician Staffed Helicopter Emergency medical services (P-HEMS) for major trauma. We identified alternative prehospital parameters in order to design a safe triage model for cancelling P-HEMS dispatches. This study prospectively measured if implementation of the new P-HEMS cancellation model is feasible, to what level the new model identifies major and minor trauma patients and if the new model will reduce over- and under triage.

Method

A prospective cohort study was performed on all trauma related dispatches for one of the Dutch P-HEMS in a six-month period. After primary triage by the EMS on scene, the P-HEMS physician and EMS crew followed the new cancellation model, resulting in either a cancellation or to continue the P-HEMS dispatch. Dispatch data were extracted from the P-HEMS database, data included: date and time, location, reason for dispatch, cancellation or continued dispatch, cancellation model followed, and the reason for not adhering to the model. The dispatches were matched to prehospital data which allowed for further retrieving in hospital outcome data such as: injury severity score (ISS), emergency intervention (EI) within six hours after arrival in the hospital, intensive care unit (ICU) admission, death prior to arrival to the hospital and-/or during hospital admission. Outcome data was compared for two cohorts, one prior and one after implementation of the model. Patients were divided into major and minor trauma patients. Sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV) for identification of major trauma of the model was calculated.

Results

The P-HEMS was dispatched 1.287 times. Of these dispatches, 1.077 dispatches were excluded, 630 due to the location of the accident being outside the research region, 165 concerned child dispatches, 149 were of non-traumatic nature, and 133 were secondary dispatches. Furthermore 23 cases had missing data. One hundred eighty-eight cases were included for analysis, with the median age being 43 years (IOR 23-62), 67% male, and the mean ISS being 16.3. When compared to the previous cohort age, EI and ICU admissions increased, whereas mortality remained unchanged. The new model identified major trauma patients with a sensitivity of 0.90, a specificity of 0.72, a PPV of 0,74 and negative predictive value of 0.889 (CI: 0.802-0.940). Yielding a potential under triage of 10.2% and an over triage of 28%.

Conclusion

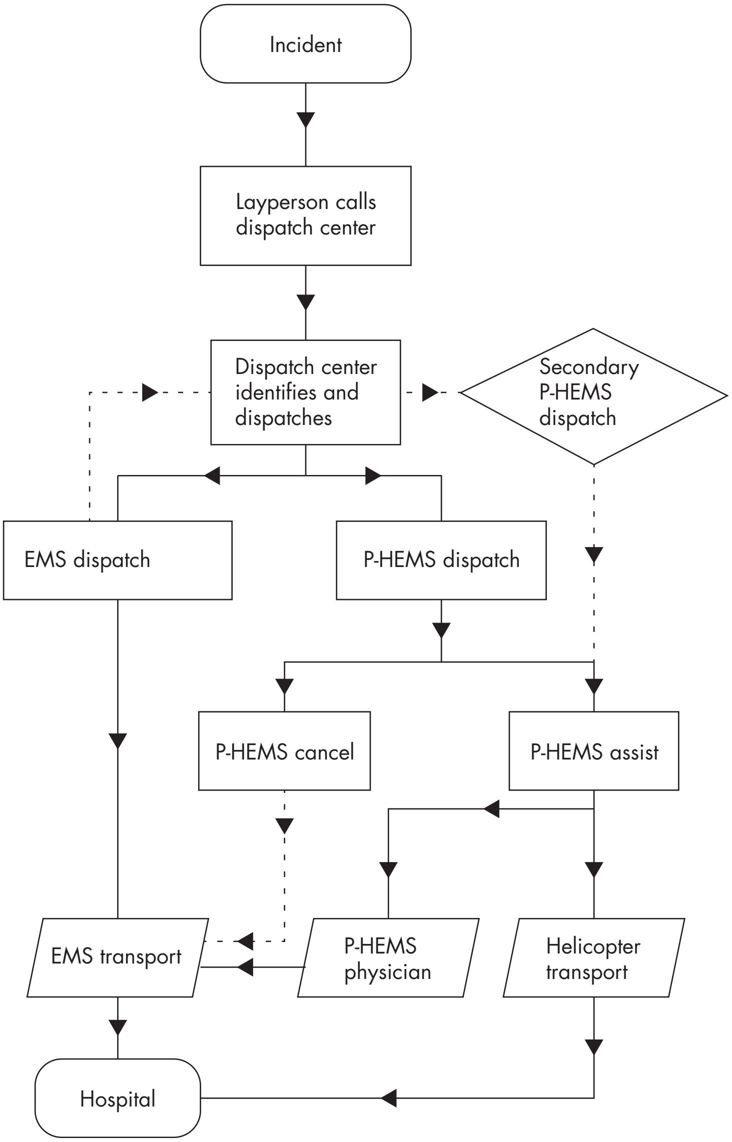
Implementation of the new cancellation model is feasible. The accuracy of the model is higher than anticipated, as are the specificity and the PPV. The new cancellation model therefore allows us to correctly identify major trauma patients with an acceptable level of over triage. Facilitating lifesaving care for the most severely injured patient whilst reducing unjustified P-HEMS dispatches.

INTRODUCTION

In the Netherlands Physician staffed Helicopter Emergency Medical Services (P-HEMS) are utilized since 1995 to complement prehospital acute care by Emergency medical services (EMS) for the major trauma patient. Since 1998 the Dutch government manages the prehospital trauma care concerning the P-HEMS and over time added three more P-HEMS teams to the Dutch pre-hospital system [1]. A P-HEMS team consists of a physician (anesthesiologist or trauma surgeon), a specialized nurse and a helicopter pilot. The P-HEMS provides comprehensive prehospital care for the major trauma patients including amongst others airway management, support of the hemodynamic status with administration of particular medication and trauma surgical interventions. Based on the initial emergency call by a layperson to the EMS Dispatch Center (DC), P-HEMS can be primary dispatched simultaneously to EMS, in the Netherlands.

EMS: emergency medical services, P-HEMS: physician staffed emergency medical services
The EMS crew usually arrives first to the scene of the accident. After evaluation on scene, EMS report back to the DC and P-HEMS with a situational report. Based on this information a decision is made to either continue or cancel the P-HEMS dispatch. Dispatch of the P-HEMS may also occur after this initial assessment by EMS crew on-scene when P-HEMS was not dispatched immediately based on more detailed information (secondary dispatch) [2,3]. The dispatch sequence can be seen in figure 1 [4]. LifeLiner One is one of the four Dutch P-HEMS teams and covers the region in the North West of the Netherlands (Trauma Region North West North (TRNWN)) 24/7. In the year 2015 the team was dispatched approximately 3.000 times, of which roughly 70% trauma-related dispatches [personal communication, 2]. The LifeLiner One uses both helicopter and car for transportation, depending on the location of the accident and weather conditions. For the LifeLiner One approximately 69% of all dispatches are done by helicopter and the remaining 31% by car, however this differs per P-HEMS [2]. Delivering appropriate and adequate care is of utmost importance to avoid preventable damage to the patient. Underestimating the severity of the patients' injury may result in deprivation of life-saving care, delayed diagnostics, inadequate treatment and inefficient resuscitative measures. To prevent under triage in our trauma system, the most logical policy seems to keep the primary P-HEMS dispatch threshold low and to develop validated criteria for the EMS crew to safely cancel the P-HEMS. To further minimize this under triage, a certain level of over triage is deemed inevitable. In P-HEMS care, over triage causes increased costs, additional safety risks to the flight crew and shortage of P-HEMS care for higher acuity emergencies [5]. Historically, acceptable under triage rates have been deemed around 5-10%, and acceptable over triage rates are between 30-50% [6]. A previous study at the VU University Medical Center showed a high cancellation rate of 21%, and relatively low predictability for major trauma [7]. Giannakopoulos et al. further identified alternative prehospital parameters in order to design a safe triage model for cancelling unnecessary P-HEMS dispatches. A new P-HEMS

Figure 1: Schedule of EMS and P-HEMS dispatch



EMS: Emergency Medical Services
P-HEMS: Physician staffed Emergency Medical Services

cancellation model was created, identifying 99.4% of the major trauma patients and had a specificity of 59.2%, a positive predictive value of 58.8%, a negative predictive value of 99.4% and an accuracy of 74.5% [7]. These findings significantly differed from the earlier used cancellation criteria. The aim of this study was to prospectively measure if implementation of the new cancellation model would be feasible, to what level the new cancellation model will identify the major trauma patient correctly and if over- and under triage for the P-HEMS will be reduced. To our knowledge, little research has been done on cancellation criteria for P-HEMS. In the Netherlands, current cancellation criteria are based mostly on expert opinion with little empirical evidence [3].

METHODS

A prospective consecutive cohort study was performed on all trauma related dispatches for the LifeLiner One in a six month period (November first 2014 trough 30th April 2015) when dispatched within TRNWN EMS-regions: North Holland North (NHN), Kennemerland (KL), Gooi & Vechtstreek (GV) and Flevoland (FL) (Fig 2.). P-HEMS dispatches to other trauma regions were excluded, pediatric dispatches were excluded, as were secondary dispatches and non-trauma related dispatches. After primary triage by the EMS on scene, whilst the P-HEMS was in flight or on route, the EMS nurse will provide the P-HEMS physician with a situational report. Based on this hand-over, the P-HEMS physician and the EMS-nurse followed the new cancellation model together (figure 3) [8]. This will result in either a cancellation or to continue the P-HEMS dispatch, taking into consideration logistical factors and dispatch conditions. Dispatch data were extracted from the P-HEMS database, which included: date and time of dispatch, location of the accident, reason for dispatch, cancelled or continued dispatch, model followed (yes, no, or not applicable), and the reason for model being not applicable. These dispatches were matched to prehospital data in the databases of the participating EMS-regions using EMS-number, time and location of the accident. This allowed retrieving in hospital outcome data using EMS arrival time's and hospital locations. Collected in hospital data were data on injury severity score (ISS), emergency intervention (EI) within six hours after arrival in the hospital, direct intensive care unit (ICU) admission, death prior to arrival to the hospital and/or during hospital admission. This study was approved by the Medical Ethics Committee of the VU medical center (2014.011) end at need for consent was waived.

Figure 2: Chart of participating EMS regions

■ Participating EMS regoins
● P-HEMS dispatch location

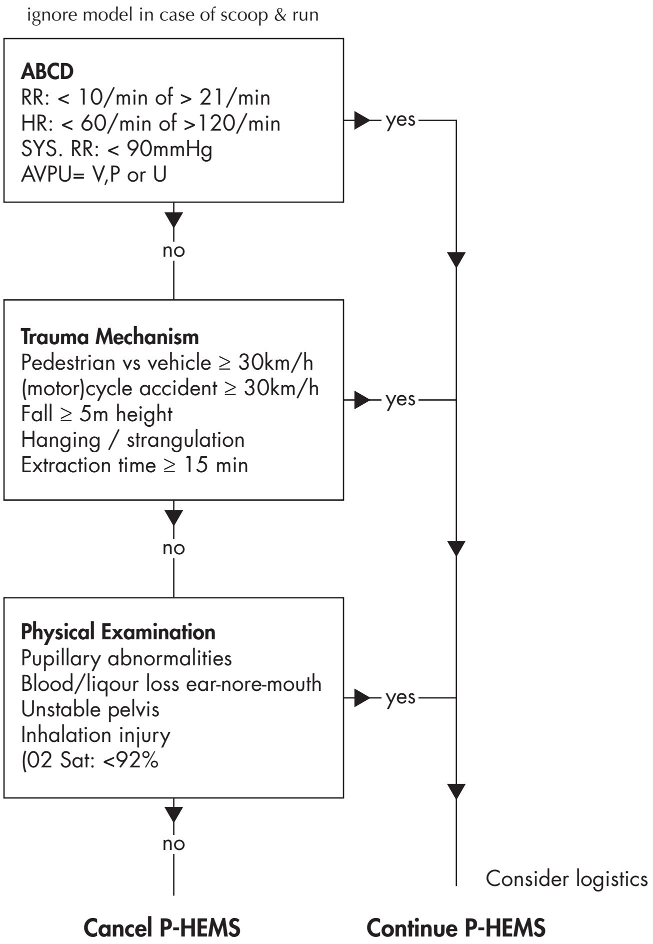
EMS: Emergency Medical Services
P-HEMS: Physician staffed Emergency Medical Services

Patients were divided into major or minor trauma patients. Characteristics of major trauma patients were defined as [9,10]:

- Injury Severity Score (ISS) ≥ 16 and-/or
- Emergency intervention within six hours after arrival in a hospital and / or
- Direct ICU admission and / or
- Death due to trauma before or during hospital admission.

The ISS version 2008 was used and was calculated from the abbreviated injury scale for each body region and represents the severity of the injuries sustained. The statistical data analysis was performed using SPSS 21.0. Statistical Analysis program (SPSS Inc., Chicago, IL). Results include descriptive statistics such as continuous data which is reported as mean values with standard deviations (SD) for normally distributed data and as median (Inter Quartile Rage (IQR)) values for not normally distributed data. The outcome of the current cohort was compared to the previous cohort prior to implementation of the cancel-model [7]. Differences in mean age, mean ISS, emergency intervention, ICU admission and mortality between the two cohorts were assessed using the Chi-square tests and for non-parametric data with a non-parametric test. Significance of statistical differences was attributed to a two tailed P value of < 0.05. The major and minor trauma patient groups were divided for continued dispatches and cancelled dispatched. The sensitivity, specificity, accuracy, positive (PPV) and negative predictive values (NPV) for the prediction of major trauma were calculated for the newly developed model and the software package Confidence Interval Analysis (CIA) was used to calculate the 95% confidence interval.

Figure 3: P-HEMS Cancellation model

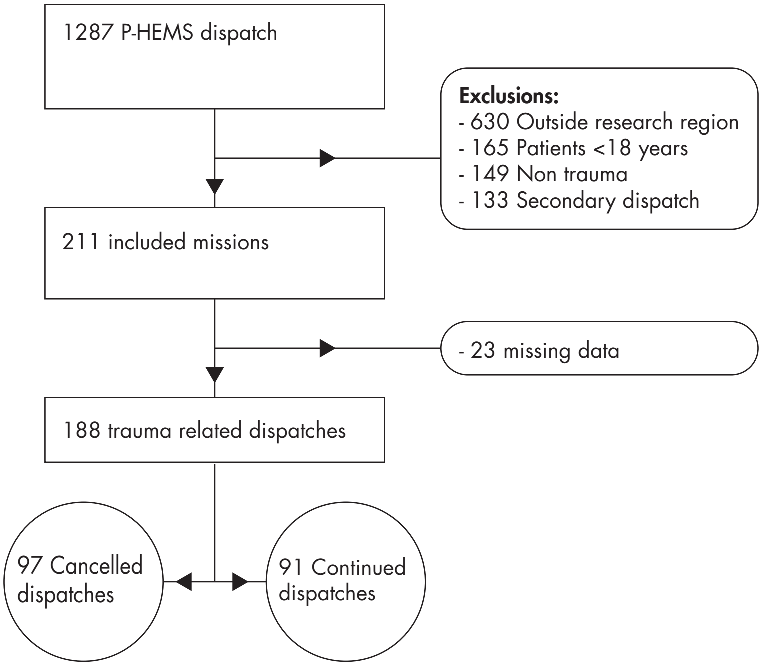


ABCD: Acronym for Airway, Breathing, Circulation, Disability, RR: respiratory rate, HR: heart rate, Sys. RR: systolic blood pressure, AVPU: acronym for Alert, Verbal, Pain, unresponsive, m: meter, min: minutes, O2 Sat: blood oxygen saturation

RESULTS

During the study period, P-HEMS were dispatched in total 1,287 times. Of these, 1,077 were excluded; 630 because the location of the accident was outside of the study region, 165 due to pediatric dispatches, 149 were of non-traumatic nature, and 133 were secondary dispatches. Furthermore 23 cases had missing data. One hundred eighty-eight dispatches were included for analysis, figure 4 shows the inclusion of cases in this study (Fig 4).

Figure 4: Flowchart of in- and exclusions in the study



P-HEMS: Physician staffed emergency medical services

Median age was 43 years, mean ISS was 16.3, median ISS was 9 and 67.2% were male. The mechanism of injury was most frequently blunt force trauma (94.6%, n = 178), only ten patients in this cohort suffered penetrating injury of which eight were stabbing injuries and two sustained gunshot wounds. In total 13 patients deceased (6.9%). Thirty-seven patients (19.8%) received an emergency intervention either by the P-HEMS on scene, in the emergency room or in the operating room, and 49 were admitted to an ICU (26.1%). Furthermore, 23 cases had missing data. In total, P-HEMS was cancelled by the on-scene

EMS-crew in 97 out of the 188 dispatches (51.6%) (Table 1). When comparing both cohorts, one can see a significant increase in mean age for the current cohort (43.0 vs 36.01, P=0.030). This is likewise seen for in the number of emergency intervention (19.8% vs 5%, P<0.001) and the number of ICU admissions (26.7% vs 15.4%, p=0.001). Furthermore, the median ISS significantly increased for the last cohort (9 vs 6, p=0.012), though the combined pre-and in hospital mortality decreased. However, this was a non-significant decrease (7.0% vs 9.0%, p=0.399) (Table 1). The patients were transported to a total of 13 different hospitals. In total 101 patients were transported to a level one, 37 to a level two and 40 to a level three trauma center, three were dead on arrival of EMS and seven received first aid at the scene, but were not transported to a hospital. The population comprised of 88 major trauma patients and 100 minor trauma patients. Of all major trauma patients, 74% was transported to a level one trauma center. Table 2 shows the division of major and minor trauma patients for continued dispatches or cancellations. Fourteen of the cancellation amongst major trauma patients were due to logistical reasons and twice due to a so called Scoop&Run. Therefore, these cancellations were further analyzed as continued dispatches (Table 2). Based on these analyses the sensitivy of the new model was 0.898 (CI:0.817 to 0.945), the specificity 0.72 (CI:0.625-0.799). The positive predictive value was 0.738 (CI:0.648 to 0.812) and the negative predictive value 0.889 (CI:0.802 to 0.9840), with an under triage level of 10.2% and an over triage level 28%.

Table 1. patient characteristics

	Current cohort N (%)	**Previous cohort N(%)**	**P value**
Median age (yr.) (IQR)	43.0 (23.00-62.00)	36.01(21.48-51.86)	0.030*
Male	119 (67.2)	273 (70.5)	0.428
Penetrating injury	10 (4.7)	14(4.2)	0.784
Cancel	101(51.0)	186 (44.1)	0.106
Emergency intervention	37 (19.8)	21(5.0)	<0.001
ICU admission	50 (26.7)	65(15.4)	0.001
Mortality within 24 Hours	13(6.9)	38(9.0)	0.399
Median ISS (IQR)	9(3-24.25)	6(1.00-16.00)	0.012*

N: number, % of reported , yr.: year, CI: confidence interval, ICU= intensive care unit, ISS= injury severity score, * tested with the non-parametric test

Table 2. Division major or minor trauma

	Major trauma	**Minor trauma**	**Total**
Dispatch	79	28	107
Cancel	9	72	81
Total	88	100	188

DISCUSSION

Creating an evidence based method for safely cancelling the P-HEMS is of imminent importance, because current practice yields high percentage under triage and is mainly based on expert opinion [3]. A new cancellation triage model was developed based on previous research in the LifeLiner One dispatch region [2,7]. This cancellation model intended to more accurately identify major trauma patients after primary P-HEMS dispatch and decrease the number of inappropriate P-HEMS assists without causing unacceptable high levels of under triage [2, 7]. This study prospectively validated the new cancellation model. Ensuring proper continued dispatches for major trauma patients and at the same time as safely cancelling for those who are perceived to be minor trauma patients. Facilitating adequate triage and patients' safety whilst reducing unnecessary utility of resources and costs. Patient characteristics regarding age, ISS and male to female ratio were equal to those reported in other national studies [11,12]. Ringburg et al. likewise report the same percentage of penetrating and blunt injuries [13]. This study shows high exclusion rates, mostly based on the location of the accident being outside the research region. Future research needs to be focused at the national implementation and validation of the cancellation model, eliminating geographical bias from the research results. Furthermore, dispatches of non-traumatic nature were a frequent reason for exclusion (12%), as were dispatches concerning children (14%). The reported number of non-traumatic dispatches in this study is higher than previously reported by Giannakopoulos et al. [2]. They report a 5% non-traumatic reason for dispatch, this discrepancy could be due to the fact that primary dispatch criteria for P-HEMS have been broadened since then, especially for non-traumatic dispatches such as, but not limited to, cardiac and septic patients [3,14]. Though the number of non-traumatic dispatches is below the numbers reported for two other Dutch P-HEMS prior implementation of the new dispatch criteria [2,3,15], the number of child related dispatches is in concordance with other P-HEMS, as well as international literature [16,17]. All the afore mentioned reasons for exclusion combined with the missing data results in a relative low number of inclusions, and form the principal limitation of the current study. Therefore, it is difficult to attribute the outcome to the model, the adherence to the model and/or the normal prehospital variation in the amount of major and/or minor trauma patients. Though the number of inclusions is lower than expected, this does not dispute the quality of the evidence delivered. The Dutch team prehospital trauma system and configuration of both EMS and P-HEMS teams is used in many different countries across the globe, amongst others the USA, the UK, Australia, German, France and Japan [18,19,20]. Therefore, lessons learned from this cancellation study could perhaps aid in more accurate cancellation systems abroad. We compared the cohort after implementation of the cancellation model with a cohort prior to implementation. When reviewing these changes, it is necessary to take into account the factor time and maturation of the trauma system in general. The comparison shows a significant increase in median age for the current cohort, which is in concordance with aging of the normal population. Furthermore, the median ISS increased. One could hypothesize this could be due to improved prehospital triage as a result of implementation of the cancellation model. Even with an increase in ISS, mortality rates remain unchanged, implying improvement in trauma care. Furthermore, the number of emergency interventions and the number of patients admitted to an ICU has increased. The new model has higher sensitivity (98.7% vs 74.5%), specificity (72% vs %9.2%) and PPV (73.8% vs 58.8%), than was earlier estimated [2]. This allows for proper identification of the major trauma patient whilst also discarding the less acuity cases. The NPV is lower than earlier presumed (88.9% vs 99.4%), though it remains within an acceptable range [2]. Additionally, for this kind of triage model we can accept a certain amount of over triage and lower NPV in order for the model to have higher PPV and lower under triage. Our model was calculated in terms of adherence to our own triage model. However, when addressing over- and under triage a posterior judgement about appropriateness should be judged externally to our triage guidelines. After careful deliberation with EMS and P-HEMS we altered the model for it to be more practical; the upper limit for respiratory rate was adjusted from >21/min to 29/min, as this is the rate already used by EMS crew and is in concordance with the Guidelines of the European Resuscitation Council [9]. Furthermore, the O2 saturation criterion was discarded. Former studies have shown the mechanism of injury (MOI) to be a parameter of extreme importance though difficult to assess by a lay person. Often being unreliable, however, it has been proven that the MOI and observer judgement (or EMS crew judgement) needs to be incorporated in the triage, otherwise dangerous levels of under triage occur [2,21]. Another possible limitation of this study is that we have only included adult patients, though inclusion of children could perhaps lead to effect modification. Further research needs to aim at likewise validating prehospital triage criteria for children who suffer trauma. Since their physiology is abundantly different one cannot simply adopt the criteria used for adults [22]. It is difficult to exactly define the type of patient in need of care by a P-HEMS team in the prehospital setting, with limited or insufficient information, this is why DC often handle low activations threshold. In the second phase of triage, a more comprehensive decision is made whether to cancel or continue P-HEMS dispatch. Therefore, it is of utmost importance to optimize this decision making process for the severely injured. This study provides a detailed scientific based guideline to safely cancel and continue P-HEMS dispatches, National implementation should consequently be considered [2,9,21].

CONCLUSION

Implementation of the new cancellation model seems feasible and safe. As mortality rates remained unchanged whilst the median age and ISS of the included patients increased. The accuracy of the model is higher than anticipated with a sensitivity of almost 90%, as are the specificity (72%) and the positive predictive value. The new cancellation model therefore allows us to correctly identify major trauma patients with an acceptable over triage level, making sure the most severely injured receive lifesaving care whilst reducing unjustified P-HEMS dispatches.

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Chapter 5

Protocol of the DENIM study: a Delphi-procedure on the identification of trauma patients in need of care by physician-staffed Mobile Medical Teams in the Netherlands

ABSTRACT

Background

In The Netherlands, standard prehospital trauma care is provided by emergency medical services and can be supplemented with advanced trauma care by Physician staffed Helicopter Emergency Medical team (P-HEAMS). Due to observed over and under triage in the dispatch of the P-HEMS for major trauma patients, the accuracy of the dispatch criteria has been disputed. In order to obtain recommendations to invigorate the dispatch criteria, this study aimed at reaching consensus in expert opinion on the question; which acute trauma patient is in need of care by a P-HEMS? In this paper, we describe the protocol of the DENIM study (a Delphi-procedure on the identification of prehospital trauma patients in need of care by Mobile Medical Teams (P-HEMS).

Methods

A national three round digital Delphi study will be conducted to reach consensus. Literature was explored for relevant topics. After agreement on the themes of interest, the steering committee will construct questions for the first round. In total, 120 panelists with the following backgrounds; P-HEMS physicians and nurses, trauma surgeons, ambulance nurses, emergency medical operators will be invited to participate. Group opinion will be fed back between each round that follows, allowing the panelists to revise their previous opinions and so, converge towards group consensus.

Discussion

Successful prehospital treatment of trauma patients greatly depends on the autonomous decisions made by the different professionals along the chain of prehospital trauma care. Trauma patients in need of care by the P-HEMS need to be identified by those professionals in order to invigorate deployment criteria and improve trauma care. The Delphi technique is used, because it allows for group consensus to be reached in a systematic and anonymous fashion amongst experts in the field of trauma care. The anonymous nature of the Delphi allows all experts to state their opinion whilst eliminating the bias of dominant and/or hierarchical individuals on group opinion.

INTRODUCTION

In The Netherlands standard prehospital trauma care is provided by emergency medical services (EMS). All EMS care providers are highly trained and registered nurses with certification in either anesthesia, intensive care, cardiac care or emergency care and additional training in prehospital trauma life support [1,2]. In order to enhance prehospital care for the severely injured patient in The Netherlands, the Mobile Medical Team, a physician staffed helicopter emergency medical service (P-HEMS), was introduced in 1995 and was extended by night flight coverage in 2006 [3]. Nowadays, The Netherlands is covered by four P-HEMS that are stand-by 24/7 and have the availability of either helicopter or road ambulance transportation. P-HEMS rapidly delivers advanced trauma life support to the trauma patient in the out of hospital setting. Dutch P-HEMS consists of either a specialized anesthesiologist or trauma surgeon and a specialized trauma nurse with at least five years of working experience in the emergency room or at the EMS. The P-HEMS supplements the prehospital trauma life support performed by the EMS with advanced trauma care according to, but also beyond, Advanced Trauma Life Support. Procedures performed are, amongst others, rapid sequence intubation, advanced pain management, and the administration of inotropes, vasopressors and other medication. Moreover, a P-HEMS can perform invasive surgical interventions such as surgical airway, intercostal drainage, splinting, thoracotomy and advanced hemorrhage control. The primary objective of a P-HEMS is swift transport of advanced trauma care to the injured trauma patient in order to perform early life saving interventions. P-HEMSs are mainly transported by helicopter (69%), but also by road [4]. In most of the cases the P-HEMS physician accompanies the patient to the hospital in the EMS road ambulance and in 5-20% of the cases the trauma patient is transported by the P-HEMS in the helicopter. At the scene, the P-HEMS physician is responsible for the prehospital logistical process. The P-HEMS physician decides on the type and order of treatment as well as to which hospital the trauma patient should be transported, based on their knowledge and experience as specialists in trauma care augmented by their frequent exposure to specific situations and patient conditions. Though P-HEMS care has been implemented for several years now, deployment of the teams could be more efficient. A study by Giannakopoulos et al. showed an over triage rate of 26% for one of the Dutch P-HEMS's [4]. Another study in the same cohort of dispatches showed that 21% of all cancellations of this P-HEMS concerned major trauma patients [5]. This may be interpreted as under triage, as this patient category is thought to benefit most by the prehospital assistance of the P-HEMS. Differences in interpretation and application of the P-HEMS dispatch and cancellation criteria by emergency medical personnel may be an underlying cause. Several reasons for this phenomenon can be listed such as regional differences in working culture (and familiarity with P-HEMS care), professional autonomy of care takers in all involved disciplines (adherence to guidelines) and a difference in trauma-related knowledge and/or exposure. Current dispatch criteria are active since June 2013 and based on two national ambulance protocols and a study by Ringburg et al. reviewing dispatch criteria [6,7]. Key topics of the current criteria are shown in Table 1.

Table 1. Fundamental tenets of the current P-HEMS dispatch criteria

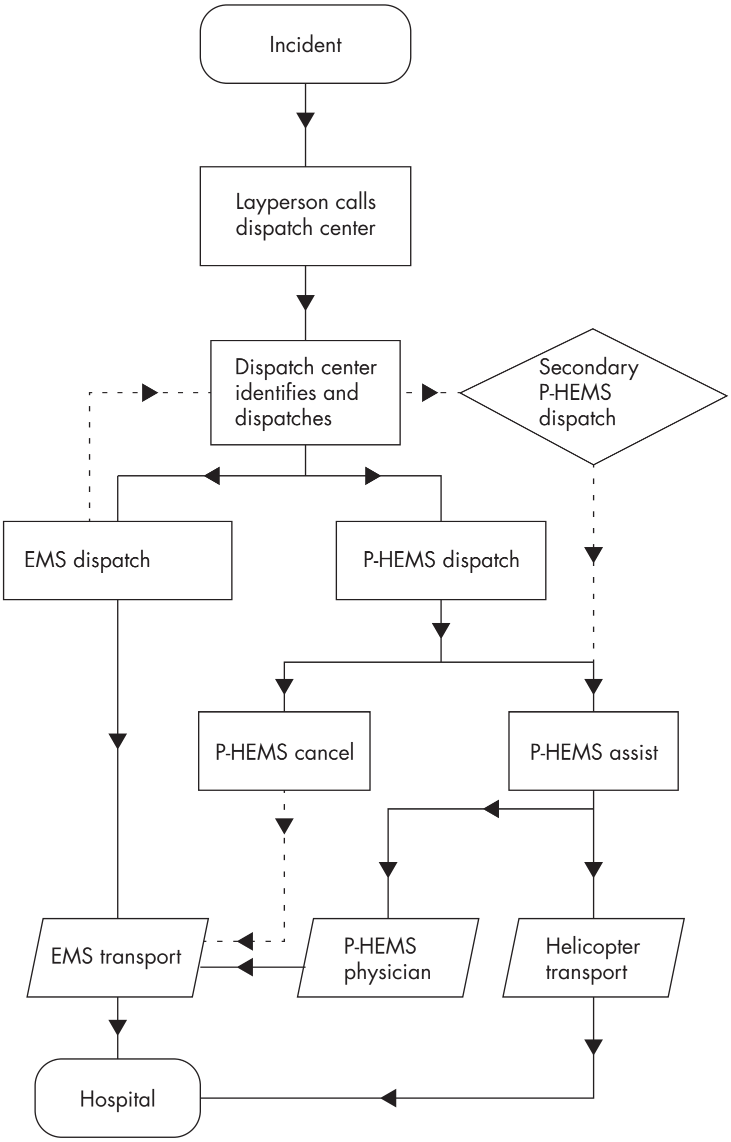
1. For the dispatch of medical personal the condition of the patient is determinative.
2. A patient with unstable vital parameters has the right to receive maximal medical care.
3. The type of care delivered is determined by the severity of the deviation in vital parameters.
4. P-HEMS care is an extension of prehospital medical care by ambulance personnel
5. P-HEMS care focuses mainly on stabilization of the vital parameters

P-HEMS: physician staffed helicopter emergency medical services

Based on these assumptions, the nature of the incident, location and time of transport appear to be of secondary importance. In the available literature, many articles describe research in the U.S. paramedic based EMS-setting or in the German physician based prehospital system-setting. The findings of this research cannot simply be compared or extrapolated to the Dutch hybrid (EMS and P-HEMS) prehospital system [4,6]. Current dispatch criteria are mainly based on level 4 evidence (expert opinion and experience), with the exception of loss of consciousness which has been proven a reliable and validated parameter for Helicopter Emergency Medical Services (HEMS) dispatch [6,8]. In the event of a severe trauma, emergency operators in the dispatch center deploy the P-HEMS simultaneously with the EMS ambulance crew (dispatch sequence is displayed in Figure 1).

The decision for dispatch is done based on information handed to the operator by a layperson. Because this information can be incomplete or incorrect, the dispatch centers handles a low activation threshold for dispatch to minimize under triage. The National Institute for Public Health and the Environment (RIVM) reports on distinct differences in the absolute numbers of dispatches between the four Dutch P-HEMSs [9]. Several possible reasons for the occurrence of these differences are suggested. Firstly, the RIVM report shows that the greater the geographical distance between the dispatch center and the P-HEMS-base, the less likely emergency operators are to deploy the P-HEMS. Organizational and management factors such as limited or insufficient protocol implementation in the dispatch center may be of influence. Finally, sociocultural aspects may play a role; including inexperience, biased working culture, individual attitudes, poor communication and levels of training of both ambulance and P-HEMS personnel [9]. The DENIM study ('DElphi studie in Nederland naar de Inzet van het MMT' Delphi study in the Netherlands on the dispatch of the Mobile Medical Team (P-HEMS)) aims at reaching consensus in expert opinion on the question; 'which trauma patient deserves the advanced care provided by a P-HEMS?'. This consensus can then be used to invigorate P-HEMS dispatch criteria in the future. The objective of this paper is to describe the design of the DENIM study.

Figure 1: Schedule of EMS and P-HEMS dispatch



EMS: Emergency Medical Services
P-HEMS: Physician staffed Emergency Medical Services

METHODS

The Delphi technique

The DENIM study uses the Delphi technique, which was initially developed in the 1950's by the RAND Corporation. This intelligence think tank designed the Delphi for use on complex problems that exceed the analytical capabilities of a single person and need to be addressed by a group of experts [10]. The Delphi technique is a structured approach of anonymous debating to generate discussion and converge toward group consensus. This is achieved through a series of rounds in which experts have to answer questionnaires [11]. The responses are then analyzed and anonymously fed back to the panelists in a subsequent questionnaire. The feedback report entails an anonymous summary of the panelist's group opinion with the associated argumentation, in order to encourage the panelist to revise their previous opinions in light of the replies of the other panelists [12]. This process may be repeated any number of times, it is thought that the group opinion will evolve towards a consensus. It is of scientific value because it can lead to an agreed set of recommendations to guidelines [13]. This study was approved by the Medical Ethics Review Committee of the VU University Medical Center.

Literature search

To construct the questionnaire, literature was reviewed to derive information on current dispatch criteria, conditions and terms of establishing dispatch criteria in other prehospital settings, information on sensitivity of separate criteria to identify major trauma patients and other factors of influence on dispatch of the P-HEMS. An electronic search in PubMed, EMBASE.com and The Cochrane Library (via Wiley) was conducted. PubMed was searched using a combination of medical subject headings (Mesh) and keywords. We applied a language restriction; English, German and Dutch articles were included. The separate results from MEDLINE, Embase and the Cochrane library were checked for duplicate articles.
All articles were reviewed and assessed for suitability based on title and abstract by two independent reviewers (AH and GG). Inclusion criteria were articles reporting on (1) trauma patients and (2) dispatch and/or cancel criteria for a P-HEMS, HEMS or physician-staffed EMS. Articles reporting (1) solely on paramedic dispatch criteria, (2) articles with no full-text available, (3) comments to other papers, (4) and editorials were excluded. Discrepancies were resolved by consensus.

Delphi steering committee

The steering committee comprises of members with an occupational background within the field of prehospital and/or in hospital trauma care. The expertness characteristics of the team include anesthesiology, trauma surgery, general surgery and P-HEMS. Furthermore, the steering committee is strengthened by a member (LM) with expertise in performing Delphi studies. The steering committee, consisting of all authors of this paper (except LM), will decide on which topics are relevant to include in the Delphi study and the type and manner of questioning. Three members of the steering committee will structure the questionnaire. The preliminary questionnaire will be send to all members of the steering committee for final comments and adjustments. The steering committee will furthermore undertake the analysis of the data, composing of the feedback documents, generating the subsequent questionnaires and overall supervision and general management of the Delphi process. The steering committee will prepare, supervises and monitor all Delphi rounds and will not take part as panel members.

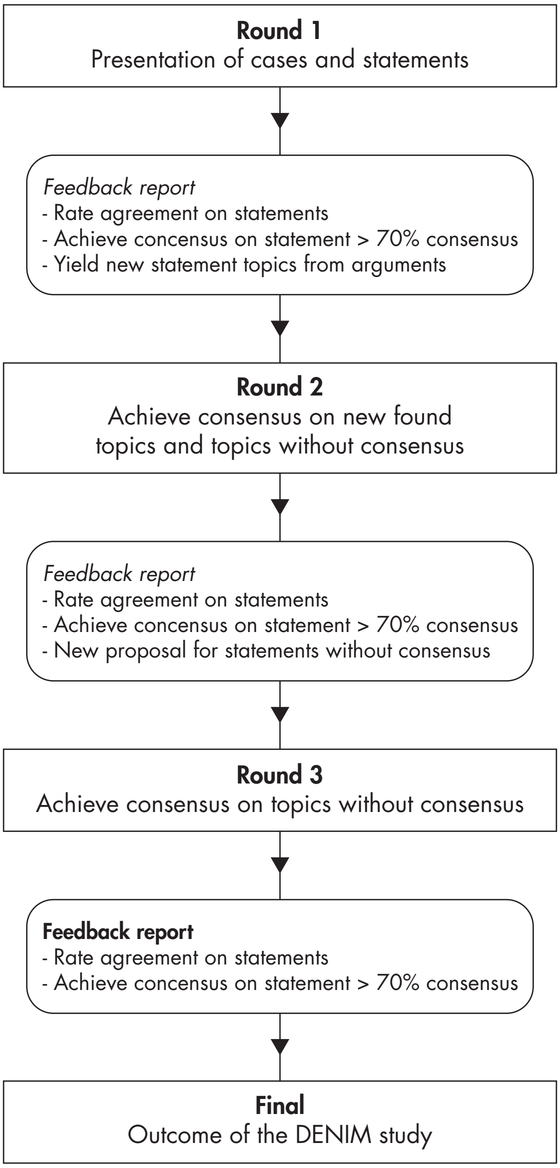
Delphi expert panel

Professionals within the field of prehospital and the in hospital trauma patient care will be recruited to participate if they have the following background: P-HEMS physicians and nurses, trauma surgeons, ambulance paramedics, emergency medical operators. Experts will be identified through nomination by steering committee members using their networks, by contacting the Dutch societies for trauma surgeons, anesthesiology and paramedics. Furthermore, the Dutch consortium for emergency medical operators will be approached as well as the chief doctors of the four Dutch P-HEMSs. Subsequently, a heterogenic expert panel will be created, in which all the disciplines involved in prehospital trauma care will be represented [14]. There are no clear numbers on adequate panel size for a Delphi study [11]. Therefore, we arbitrarily decided that a panel had to consist of at least 10 experts per category of expert background to be adequate, a combined total of approximately 50 members. In previous Delphi studies the maximum response rate is up to 70% for the first round and 50% will suffice to complete the entire survey [15,16]. Therefore, approximately 120 panelists will be solicited to participate. All eligible panelists will be contacted via email, introducing the Delphi study and asking them to participate. Background information on the aim and course of the study will be given. Experts who do not respond will be reminded twice. When less than 70 panelists agree to participate, 50 more panelists will be invited while keeping in mind that all different disciplines need to be represented equally to ensure heterogeneity. Panelists will remain anonymous throughout the entire study. The research coordinator has access to panelists information for logistical reasons.

The Delphi structure

The DENIM study is structured as a three round digital Delphi procedure (Figure 2). In the first round the mean question is; which trauma patient deserves the advanced care of the P-HEMS? In order to generate discussion varying statements and cases will be introduced to the panel in the first round. The answers will be used to identify topics of interest leading to statements that will be tested in the subsequent round. Statements will be tested for level of agreement on a Likert scale. Moreover, distinctive concepts will be presented to the panelists, for instance scoop and run, stay and play or the use of neurological scales. Panelists will be asked what description they think best suits the concept or how they would assess the patient's condition using different scales. For all questions, panelists will be asked to motivate their opinion in an obligated open comment box before they can proceed. In the pre text, it is stated that the motivation to their answers is of critical importance for the subsequent round of the Delphi.

Figure 2: The Delpi procedure for the DENIM study



Delphi questionnaires

The steering committee will develop the questionnaire for the first round. A list of themes and ideas of interest was constructed and mandatory topics were identified (Table 2). The questionnaires of all rounds will be designed and distributed using the online survey program SurveyMonkey®. In the first questionnaire, the main priority is to yield arguments and motivation. Three types of questions will be presented to the panelists (Table 3). Cases will be presented and panelists will be asked, if they think that P-HEMS care is indicated. Furthermore, open questions regarding definitions in trauma care and/or the type of treatment that is preferred in specific situations will be presented. Moreover, panelists will be asked if they agree or disagree with statements that are presented. Considerations supporting their opinion should be stated after each question. Answers will be analyzed using descriptive statistics and a sum of at least 70% of the experts that either totally agreed or agreed will be considered agreement as well as for disagreement. The first round will be assessed by an independent physician for feasibility and duration of undertaking the questionnaire before sending it to the panelists. In round two, a selection of questions derived from round one on the topics with no agreement nor disagreement will be retested using questions that elaborate on the subject. Furthermore, new topics will be introduced that have derived from the argumentation and considerations of the panelists and will likewise be tested.

Table 2: List of relevant themes for the steering committee meeting

Themes prior to SC meeting	Additional topics after SC meeting
1. Responsibility	1. What is a poly trauma patient
2. SitRap / Mist	2. Vital parameters/ physiology
3. Expertise/ Exposure	3. Patient characteristics
4. Logistics	4. Mechanism of trauma
5. Soft skills	5. Practical feasibility
6. Literature	6. Current dispatch criteria
7. Reason of dispatch	7. Communication
8. Regional differences	8. Surgical interventions
9. Prehospital judgement of o.a. consciousness	
10. Advance analgesia	
11. Function of the P-HEMS	
12. Overview of integrated care	
13. On-scene-time	

SC: steering committee SitRap: situational report

Table 3. Type of questions used in round one

Type of question	Topic a.o.	Answer
Cases	P-HEMS presents	'yes', 'neutral' or 'no'
Open questions	EMV/AVPU	Open text field
Statements	Treatment options, parameters, patient characteristics, judgement	5-point Likert scale, ranging from "I totally agree" to "I totally disagree".

P-HEMS: Physician staffed Helicopter Emergency Medical Services, EMV: element of the Glasgow coma scale, AVPU: acronym for measurement of patient's level of consciousness (alert, voice, pain, unresponsive)

Feedback

After each round results and argumentations of the previous round will be fed back to all panelists in an anonymous report including results and all argumentations given. The argumentation and comments given by panelist will be used to construct the subsequent questionnaire by the steering committee. The feedback reports will be supplemented to the questionnaire of the next round. The answers and comments will be presented both quantitatively (the distribution and sum of the agreement and disagreement per question) and qualitatively (the argumentation and comments of the panelists per statement) as well as whether or not agreement has been reached.

Results

The objective of the DENIM study is to reach expert consensus on the question which trauma patient deserves the care of a P-HEMS. This consensus will provide recommendations with which P-HEMS dispatch criteria can be invigorated. This may lead to a more efficient deployment of the P-HEMS for trauma in the Netherlands.

DISCUSSION

A Delphi technique is used for this study because it allows for group consensus to be reached amongst experts on a complex issue [11]. Due to the complexity of the prehospital decision-making-process, it is not feasible to generate a "one-size-fits-all" model. However, consensus can help to develop practice guidelines (i.e. dispatch criteria) and leave enough space for a patient tailored approach by professionals. Our research question cannot be addressed utilizing prospective trials because of ethical issues since P-HEMS trauma care has been institutionalized for decades. However, a Delphi procedure is a suitable research method because it is designed as an iterative process to combine expert opinion into group consensus [11]. It easily solicits the opinion from dominant, geographically dispersed and time poor experts, which are often the case with P-HEMS-personnel, ambulance staff and trauma surgeons. One could debate that the Delphi does not correctly represent expert opinion as it is not a strict scientific untenable approach [17]. For instance, because the Delphi procedure does not use a random sample for selecting panelists. Therefore, one has to ensure an accurate representation of the target population through a thorough selection process of respondents. To overcome this dilemma, criteria for qualitative studies are applied to help ensure credible interpretations of the findings. These criteria are based on the pillars of qualitative research such as; credibility, applicability and conformability [18]. We create 'safety in numbers' and the heterogeneity of the working background of the included panelists. This because panels comprising of similarly trained experts provide an effective and reliable utilization even of a small sample of experts and have proven to be a good base for the development of informed and effective decision-making criteria [19]. These decisions are strengthened by the utilization of reasoned arguments and assumptions that are challenged within this Delphi through feedback [20-22]. Feedback can be presented as a statistical group response, such as a measure of variance, along with that of central tendency of group opinion, accompanied by argumentations and comments provided by individual panelists [23]. Furthermore, it has been stated that results of a Delphi procedure are weakened, because it does not allow discussion amongst experts directly [24]. However, the anonymous nature of the Delphi allows for a reduction of the biasing effects of dominant individuals in group-based discussion processes [14,25], especially in a hierarchal environment such as the Dutch healthcare system. It is essential that the validity of consensus depends on a sufficient response rate throughout all three iterations thus preventing a reduction in the quality of the information generated [26].

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Submitted

Chapter 6

National consensus on prehospital trauma care, the results of the DENIM study.

ABSTRACT

Introduction

Physician staffed Helicopter Emergency Medical Services (P-HEMS) are an extension to the standard prehospital trauma care that is provided by emergency medical services (EMS) paramedics. For specific cases, injuries or trauma mechanism the P-HEMS team is dispatched to aid EMS in their care for the severely injured patient. Prehospital communication is a factor of influence on the identification of the severely injured, on proper deployment of medical recourses and collaboration between all types of EMS. However prehospital communication it is often incomplete and unstructured. To gain insight on expert opinion and generate scientific evidence, on the dispatch of P-HEMS and communication between EMS a Delphi study was performed.

Methods

A three round Delphi study was designed to explore concepts amongst experts in prehospital trauma care. P-HEMS physicians/nurses, trauma surgeons, ambulance paramedics and emergency medical operators where asked to state their opinion regarding identification of the poly trauma patient, trauma patient characteristics, prehospital communication and prehospital handover.

Results

Sixty-four panelist completed all three rounds. For the first round seven cases and 14 theses were presented. From these answers/argumentation the second round was build, in which 68 theses had to be ranked within four principle themes: factors that influence prehospital communication, critical information for proper handover, factors influencing collaboration and how training/education can influence this. Out of these answers the third survey was build, focusing on determining the exact content of a prehospital trauma handover. The majority of the experts agreed to a set of parameters resulting in a new model of inter-professional handover regarding prehospital trauma patients.

Conclusion

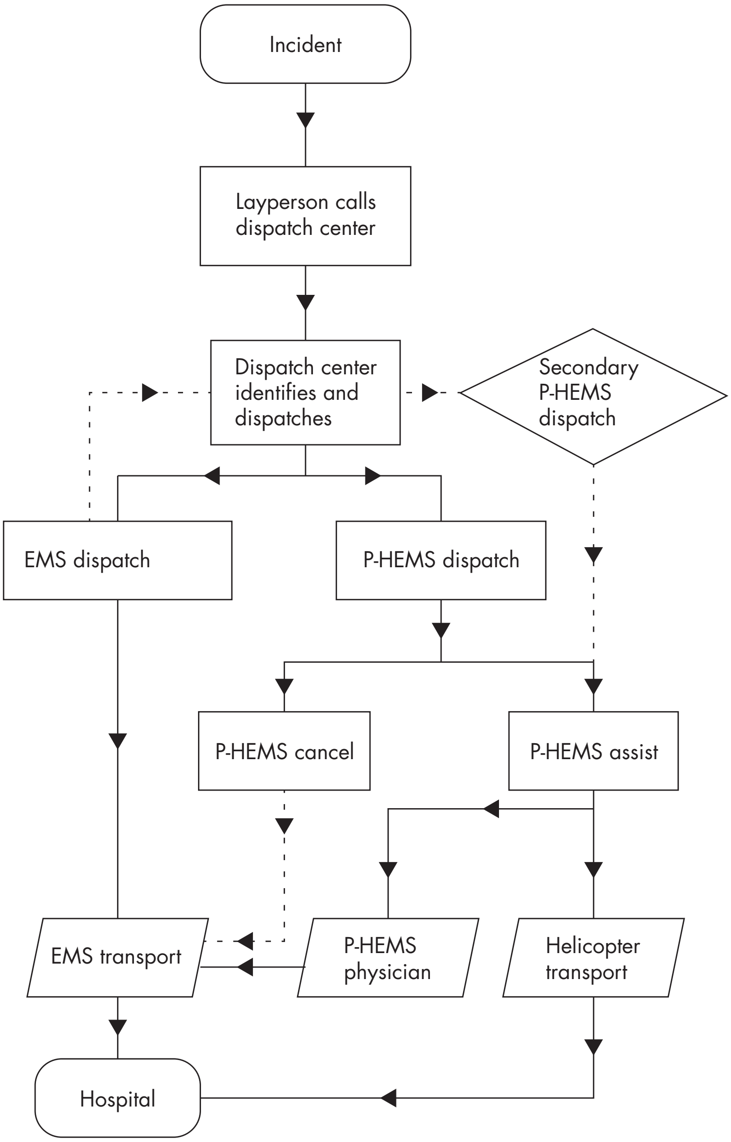
This study explores opinions regarding identification of the poly trauma patient, trauma patient characteristics, prehospital communication and prehospital handover. The respondents of the DENIM ('Delphi studie in Nederland naar de Inzet van het P-HEMS', Delphi study in the Netherlands on the dispatch of the Mobile Medical Team (P-HEMS)) report that prehospital communication needs to be unambiguous to improve trauma care. Consensus was reached on a set of ten parameters that should minimally be handed over with regard to a prehospital trauma patient. This to facilitate prehospital communication between the Dispatch center, EMS, P-HEMS and the receiving hospital.

INTRODUCTION

Physician staffed Helicopter Emergency Medical Services (P-HEMS) are an extension to the standard prehospital trauma care that is provided by Emergency Medical Services (EMS) paramedics. For specific cases, injuries or trauma mechanism the P-HEMS team is dispatched to aid EMS in their care for the severely injured patient. [1, 2]. In the Netherlands there are four P-HEMSs available 24/7 since 2011, covering almost the entire country. Two border regions are also covered by German and Belgium P-HEMSs [3]. A P-HEMS comprises of a pilot, a doctor which is either a trauma surgeon or anesthesiologist and a nurse. They provide additional prehospital care beyond the scope and skill of EMS, via lifesaving interventions according to advanced trauma life support guidelines [4]. Amongst others intubation, sedation, administration of analgesia, inotropes, vasopressors and the P-HEMS physician assisted by the P-HEMS nurse is able to perform invasive surgical interventions. This is done to bring a level of hospital skills and performance to the patient in and out-of-hospital setting. There is debate on the accuracy of the dispatch criteria for the P-HEMS. This debate is due to differences in interpretation of the dispatch and cancel criteria, regional difference in usage of the criteria, feeling of professional autonomy of the EMS, local and cultural aspects regarding P-HEMS care, knowledge or exposure of the EMS to severely injured patients and the little empirical data available on the care provided by the P-HEMS in the Dutch system. Current dispatch criteria are active since June 2013 and solely based on two national EMS protocols and one study by Ringburg et al. reviewing dispatch criteria [5]. This is mainly due to the fact that international prehospital trauma literature is not simply applicable to the Dutch hybrid prehospital EMS system [5, 6]. Current dispatch criteria are therefore mainly based on experience and expert opinion (level IV evidence) [7]. Emergency operators in the EMS dispatch center dispatch either EMS solely or EMS and P-HEMS simultaneously (figure 1 shows the dispatch sequences [8]).

This dispatch is based on information handed to the operator by a layperson. This information can be incomplete or incorrect. Therefore a low activation threshold is used to minimize under triage. To gain more insight, address the lack of literature and develop consensus on what type of patient deserves the additional care of a Mobile Medical Team, generating an expert based standard for identifying the critically injured patients the DENIM ('Delphi studie in Nederland naar de Inzet van het P-HEMS', Delphi study in the Netherlands on the dispatch of the Mobile Medical Team (P-HEMS)) was developed. The DENIM aims at reaching consensus in expert opinion on the question how can prehospital trauma care be improved? Amongst others by trying to identify which trauma patient would benefit from the advanced care provided by a P-HEMS, which factors are of influence and how prehospital collaboration can be optimized. This paper is a part of a wider investigation on how to improve prehospital trauma care for the severely injured.

Figure 1: Schedule of EMS and P-HEMS dispatch



EMS: Emergency Medical Services
P-HEMS: Physician staffed Emergency Medical Services

METHODS

Delphi Technique.

The Delphi technique is a well-recognized method for consensus generation amongst a group of experts through several iterations of questionnaires [9, 10]. The technique is designed as a group communication process, to achieve consensus and generate qualitative data on topics which are difficult to address via clinical trials, via a series of questionnaires [11]. The responses are then analyzed. The group's response and associated argumentation is fed back to the panelists in an anonymous matter combined with the next questionnaire. This allows panelist to revise their previous opinions in light of the answers and arguments of the other panelists and allow the group to converge to an average group opinion [12]. Avoiding an individual's opinion to be biased by influential factors such as hierarchy and peer pressure.

Design of the DENIM.

The DENIM comprises of three subsequent online questionnaires and is of scientific value because it can lead to an agreed set of recommendations to guidelines [8, 12]. The detailed protocol of the DENIM has been published previously [8]. In brief, all internet-based questionnaires were designed and distributed via the online survey program SurveyMonkey®. In order to construct the questionnaire, literature was reviewed on current P-HEMS dispatch criteria, both in The Netherlands as for other countries. Information on prehospital triage and other factors that might be of influence on dispatch of the P-HEMS were reviewed. The literature search was done according to PRISMA guidelines [14].
The literature was reviewed by the DENIM Steering Committee (SC), which comprises of members with an occupational background within the field of pre- or in hospital trauma care (trauma surgery, anesthesiology, P-HEMS) and extended by a member with knowledge on performing Delphi studies. The SC, consisting of all authors of this paper, assessed which topics were relevant and constructed a list of themes and ideas of interest. Four members of the SC structured all the questionnaires and all members of the SC had the ability to revise and approve each questionnaire prior to deployment. The SC thus prepared, analyzed, supervised and monitored all Delphi rounds and did not take part as panel members.

The DENIM expert panel

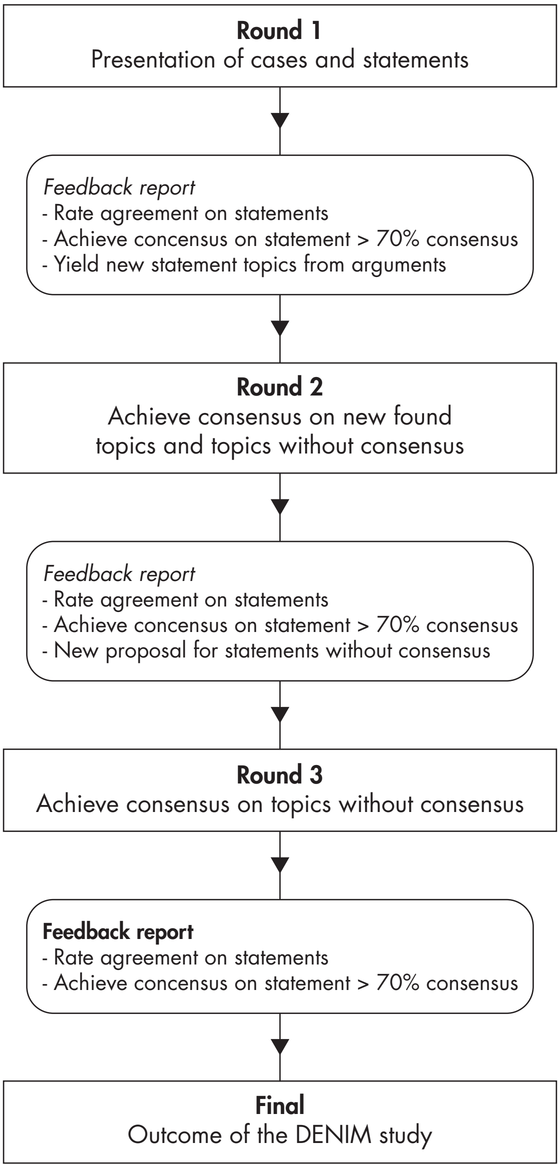
The respondents recruited to participate were professionals within the Dutch field of pre- and in hospital trauma care (P-HEMS physicians and nurses, trauma surgeons, EMS personnel and emergency medical operators). The experts were contacted via Dutch consortia and national societies of the specific occupational groups. Creating a heterogenic expert group in which all disciplines involved in prehospital trauma care were represented and divided across the country minimizing bias due to local culture and geographical differences [15]. Approximately 120 panelists were asked to participate via email.

Background information on the aim and course of the study was given. Panelists remained anonymous throughout the entire study. Anonymity was deemed critical to the process in order to facilitate the freedom for respondents' to express their views on sometimes sensitive topics.

The DENIM rounds

For the first DENIM round, the main question asked was; which trauma patient would benefit by the advanced care of P-HEMS? In order to generate discussion and yield argumentation varying statements and cases were presented. The answers were used to identify topics of interest leading to statements that were presented in the subsequent round. In order to motivate their opinion panelists were obligated to fill out the open comment box. A detailed overview of the DENIM can be found in the published protocol [8]. From the first round we could conclude that it was difficult to identify what patient would benefit by the care of a P-HEMS. It appears that the identification of the major trauma patient is problematic. Additionally prehospital communication on parameters, such as vital signs, for major trauma patients is often sparse and inadequate. The SC deemed it necessary to further look into the prehospital communication, mode and content of the prehospital communication before being able to answer the primary research question. It was thought that when prehospital communication becomes more clear and accurate the P-HEMS dispatch can be evaluated more adequately allowing for an adjustment in dispatch criteria that may improves prehospital trauma care.

Figure 2: The Delpi procedure for the DENIM study



DENIM: ‘Delphi studie in Nederland naar de Inzet van het P-HEMS’: Delphi study in the Netherlands on the dispatch of the Mobile Medical Team (P-HEMS)

For the second round topics from the first were fed back and further investigated such as interpretations of the Glasgow Coma Scale (GCS), advanced pain medication, AVPU scale (acronym from “alert, voice, pain, unresponsive”), method for providing a situational report, scoop and run, stay and play, justification of dispatches based on mechanism of injury (MOI) or injuries sustained, dispatches based on penetrating trauma, influence of extremes in ages, usage of the acronyms for reporting.

However focus of the second questionnaire was on prehospital communication. Main topics here were evaluating factors influencing prehospital communication, critical information for proper handover, factors influencing collaboration and how these can be influenced from a training/educational perspective? From answers on the second questionnaire the SC converged further to the third round, which was aimed at exactly establishing the content of a prehospital handover. Figure 2 shows an overview of the DENIM structure [8]. Several types of questions were presented to the panelists. Firstly cases were presented and panelists were asked whether they thought that P-HEMS care was indicated. Open questions regarding definitions in trauma care were presented. Furthermore statements were presented and panelists were asked to if they agree or disagree to the statement, using either a five-point Likert scale (totally agree, agree, neutral, disagree, totally disagree) or a three-point Likert scale (agree, neutral, disagree).

Data analysis

A two stage qualitative and inductive ‘thematic analysis’ was undertaken, to analyze the results of the first round and to minimize redundancy by grouping similar ideas together [16]. Two authors assessed the results independently and identified broad coding themes. These were discussed and agreed by the entire SC. The data was entered into the SPSS statistical software package version 22 and analyzed to examine level of agreement. Answers were analyzed using descriptive statistics. When at least 70% of the experts that either agreed or disagreed was considered consensus. Percentage between 55% and 70% was considered as tendencies towards consensus, everything below 55% was considered non-consensus (Table 1 shows all possible outcomes of consensus). Ethical approval for this study was granted by the local Medical Ethics Review Committee.

Table 1. Possible group outcome for the statements

Answers	Group	Symbol
> 70% Of the respondents agrees with the statement presented.	Consensus to agreement	Y+
> 70% Of the respondents disagrees with the statement presented	Consensus to disagreement	Y-
55-70% Of the respondents agrees with the statement presented	Tendency to agreement	T+
55-70% Of the respondents disagrees with the statement presented	Tendency to disagreement	T-
Everything <55% for agreement and disagreement	Non-consensus	N

RESULTS

Round 1

Hundred-twenty panelists were contacted, 83 participated. In the first round 80% (N=65) of the respondents was male, 20% (N=18) female. Twenty-seven respondents were P-HEMS-physicians, 17 P-HEMS-nurses, 13 ambulance nurses, 17 dispatch operators and 27 trauma surgeons. Concerning the heterogeneity, fourteen out of seventeen Regional EMS services were represented in the panel, all four P-HEMS teams were represented equally and eight out of 11 Dutch trauma centers were represented.
In order to generate discussion and yield argumentation on the research question seven cases and 13 statements were presented. An overview of the results of the first round can been seen in table 2. Below we further elaborate on the argumentation yielded in this round.

Table 2. Overview of the result of the first round

No	Case topic	N	%	Consensus
1	Value P-HEMS in TBI case	78	23	N
2	Value P-HEMS in rapid sequence intubation	77	62	T+
3	Value P-HEMS in pediatric TBI, assessment of GCS	77	63	T+
4	Pain management and transport time	75	36	N
5	Usage of the AVPU scale for neurological assessment	75	51	N
6	Definitions of “Scoop and Run” and “Stay and Play”	75	67	T+
7	Treatment of a bleeding scalp injury	75	43	N

No	Statement topic	N	%	Consensus
1	P-HEMS shortens time to definite care	74	27	N
2	Primary dispatch P-HEMS strictly based on information on the MOI	74	78	Y+
3	the ‘D’ is more important than the ‘A,B,C’ for dispatch of P-HEMS	74	78	Y-
4	P-HEMS dispatch for patients suffering penetrating trauma	74	64	T-
5	Variability in the relative dispatch frequency per EMS dispatch region	74	55	T+
6	Extrication time > 20 minutes P-HEMS dispatch is indicated	73	58	T+
7	victim ejected from vehicle is an adequate dispatch criterion	73	80	Y+
8	Extremes in ages adequate dispatch criterion	73	44	N
9	RTS below 12 is an adequate dispatch criterion for the P-HEMS	73	38	N
10	On the importance of the MOI for the dispatch of P-HEMS	73	84	Y+
11	The importance of the injuries sustained for the dispatch of P-HEMS	73	96	Y+
12	The value of patient’s vital signs for the dispatch of the P-HEMS	73	95	Y+
13	The influence of logistical factors for the dispatch of the P-HEMS	73	78	Y+

P-HEMS: Helicopter Emergency Medical Services, TBI: traumatic brain injury, GCS: Glasgow Coma Scale, AVPU: neurological scale (alert, verbal, pain, unresponsive), MOI: Mechanism of Injury, EMS: Emergency medical services, RTS: Revised Trauma Score, N= Non consensus, T+ Tendency to agreement T-: tendency to disagreement, Y+ consensus on agreement, Y-: consensus on disagreement

Cases round 1

Case 1: Is on the value of the P-HEMS in a case of Traumatic Brain Injury (TBI). There was no consensus (N). Main topics of argumentation that arose were on prehospital communication, professional assessment of the situation and frequency of exposure. It was frequently stated by the respondents that reporting “ABCD-stable” is insufficient for a handover or for decision making because it provides too little information on the patients status. Additional information, for example vital parameters, Glasgow Coma Score (GCS) or AVPU (Alert, Verbally, Pain, and Unresponsive), pupils, lateralization, headache, medication (anticoagulation) and loss of consciousness, are often reported as parameters of critical importance for a proper situational assessment. It is opted that the MIST-method (Mechanism of injury (MOI), injuries found and suspected, vital Signs and treatment given) is a more appropriate method for handover because it is more comprehensive and gives more valuable information. It is stated that when an EMT nurse identifies a patient is “ABCD-stable”, P-HEMS should rely on the assessment done by the EMS. This however is questioned due to the assumed low exposure of the EMS nurses to poly trauma patients. Additionally one can conclude that ABCD stability assumes that there is no loss of consciousness, a maximum GCS and no need of care by a P-HEMS.
Case 2: is on the additional value of the P-HEMS for Rapid Sequence Intubation as a part of pain management in a case of multiple fractures. There was a tendency to consensus. Main topics of argumentation that arose were the complexity of the case, again frequency of exposure and the professional expertise. It was often mentioned that P-HEMS dispatch for adequate pain relief during transport is justified. Furthermore it is thought that the P-HEMS physician has better insight in the pre-operative planning which may contribute to a swifter logistical process. It is acknowledged that the neurological status needs to be evaluated properly prior to prehospital intubation or sedation. Question arises whether or not pre-hospital intubation is optimal treatment for a patient, considering the suboptimal conditions in the prehospital setting.
Case 3: is a pediatric TBI case. The proper assessment of the GCS and the additional value of the P-HEMS were questioned. There is no consensus on the interpretation of the GCS, there was a tendency to consensus toward the GCS of the child being below fifteen (63%, T+). The range of reported GCS is wide, varying from eight to fifteen. There is no consensus (N) on the additional value of the P-HEMS in this case. Though there is consensus to agreement on the additional value of the P-HEMS in case of a GCS below eight (63%, Y+). Main topics of argumentation that arose were on prehospital communication, applicability of the GCS for children, ability to assess the neurological status, frequency of exposure and insufficient data for decision making. It is mentioned that interpreting GCS can be quite difficult especially in case of limited details and in juvenile cases. Though the usage of the AVPU method is opted frequently, which is more easy to use but also lacks detail. Furthermore it is mentioned that the GCS is a measurement to be used cross-sectional. It should not be used for evaluative purposes to monitor the neurological course over time, thus not depicting deterioration or improvement. What also arises is that the usage of the GCS is difficult when a patient is intoxicated, often resulting in a lower GCS but not

necessarily in need of more advanced care.

Case 4: Ideal pain management in isolated femoral fracture with moderate transport time. There is no consensus (N) on what type of analgesics should be used. Topics that arose were the unfamiliarity or unawareness with certain types of advanced pain medication amongst ambulance nurses, or the type of advanced pain management the P-HEMS can provide.

Case 5: is on the suitability of the use of AVPU-scale as handover for the neurological status and the additional value of the P-HEMS in case a trauma patient scores a V (verbal) on the AVPU scale. There is no consensus on the usage of the AVPU-scale or on the additional value of the P-HEMS. Main topics that arose were that professionals in the field of prehospital trauma care should be able to give an appropriate GCS. Moreover, an AVPU score gives too little information for adequate decision making, however is arguably easier to use. Concerns however, are often raised to the adequacy of professional assessment of neurological status, especially when reporting the GSC.

Case 6: is on the definitions 'scoop and run' (SR) and 'stay and play' (SP) and the additional value of the P-HEMS in a case of SR. There is a tendency to consensus on the case depicted being a SR case. There is no consensus on the additional value of P-HEMS. Main topics that arise are that there is still much debate on the exact definitions of the terms and that the terms perhaps should be discarded in the prehospital communication. It is opted that a patient who is hemodynamic unstable could benefit from the care of a P-HEMS but dispatch should be cancelled or continued in light of logistical factors such as arrival time or a rendez vous.

Case 7: is on the preferred method for treating a severely bleeding scalp laceration and the additional value of the P-HEMS in this case. There is no consensus (N) on the preferred method, though 43% would opt using hemostatic compression band aid. There is no consensus (N) on the additional value of the P-HEMS. Main reasoning was on unawareness of treatment options, unawareness of logistic options and frequency of exposure.

Statements round 1

Statement 1: "Presence of the P-HEMS shortens time to definite care." There is no consensus. Arguments raised are that the definition on definite care differs, a P-HEMS is able to bring certain in hospital care to the patient and therefore shortens the time to receive advanced medical care. This however, may consequently increase prehospital time.

Statement 2: "It is justified to primarily dispatch a P-HEMS strictly based on information on the MOI." There is consensus for agreement. Main argumentation is that for the primary dispatch the threshold should be kept low and that MOI corresponds well with severity of trauma, though it is said that MOI should be used in combination with other parameters such as patient's vital signs.

Statement 3: "In general the 'D' (Disability, neurological status in ABCDE-method) of the patient is more important than the 'A, B, C' status for the dispatch of the P-HEMS." There is consensus for disagreement. Main reasoning is that patient's condition in the A and B should be leading, according to the ATLS guidelines, and that the additional value of the

P-HEMS is also high for abnormalities in the neurological status. It is stated that patients who suffer a D abnormality are prone for having a deviation in the A or B.

Statement 4: "P-HEMS dispatch (including a rendez vous) for patients suffering penetrating trauma to the chest, abdomen or neck is not indicated unless prehospital transport time will take more than 20 minutes." There is a tendency to disagreement. Topics of reasoning that arise were that advanced surgical trauma care should be provided to the patient as soon as possible, taking into account the prehospital logistical process, this could either be in the ER or on the scene. What also arises is the unawareness of treatment options in the prehospital setting for this group of patients, complexity of case and that the frequency of exposure being low amongst EMS personnel.

Statement 5: "There is a variability in the relative dispatch frequency of the P-HEMS per EMS dispatch region, reasons for this could be:" The two most chosen reasons were the culture in the dispatch center and geographical/logistical factor.

Statement 6: "When extrication time is thought to be more than 20 minutes P-HEMS dispatch is indicated." There was a tendency to agreement. Topics of reasoning are on the exposure of the ambulance nurses, the expectancy that prolonged entrapment may result in a higher risk of hemodynamic deterioration, however this differs per case of entrapment.

Statement 7: ""victim ejected from a vehicle" is an adequate dispatch criterion for the P-HEMS." There was consensus on agreement. Main argumentation is that this is often a high energy trauma which correlates with high risk on severe injuries.

Statement 8: "Extremes in ages (ages below twelve or above 65) are an adequate dispatch criterion for the P-HEMS. There was no consensus. It is opted that victims included in these groups can be fragile. Though, it is difficult to know the exact age in the prehospital setting and age does not necessarily reflect patient's condition.

Statement 9: "RTS below 12 is an adequate dispatch criterion for the P-HEMS." There was no consensus. It is said that the usage of this score in the prehospital setting is too difficult, that it does not portray the condition of the patient properly, should not be used as mono-criteria for dispatch and that the parameters on which the score is based are of more value separately.

Statement 10: "Is on the importance of the MOI for the dispatch of the P-HEMS." There was consensus to agreement. It is mentioned to be a good indicator for the severity of injury of the patient, though it should not be used as a single parameter. Dispatches are mainly based on the appeal of a layperson of whom the description of the MOI is not always reliable.

Statement 11: "Is on the magnitude of the injuries sustained for the dispatch of the P-HEMS." There was consensus to agreement. Main argument is that injuries sustained are critical for the outcome of the patient, though it should be a supportive parameter in addition to patient's vital signs or other additional information.

Statement 12: "Is on the value of patient's vital signs (ABCD) for the dispatch of the P-HEMS." There was consensus to agreement. Main topics of reasoning are that this gives insight in the hemodynamic condition of a trauma patient, in combination with the MOI it gives insight into the risk of deterioration but logistics should also be taken into account.

Statement 13: "Is on the importance of logistical factors for the dispatch of the P-HEMS." There was consensus to agreement. Main topics of arguments are that swift transport to the nearest trauma center is most beneficial for the patient, in some situations air transport can be of additional value, though it is stated that waiting for P-HEMS to arrive is unacceptable. Furthermore it is stated that the Dutch prehospital system has a very dense availability of ambulances and level 1 trauma centers and therefore short arrival and transport times.

Round 2

After round 1 we continued with four topics as decided by the SC. Hundred-twenty panelists were contacted of which 79 participated. Sixteen respondents were P-HEMS-physicians, eight P-HEMS-nurses, 27 EMS personnel, nine dispatch operators and 24 trauma surgeons. Statement were presented on topics regarding (1) P-HEMS dispatch, (2) collaboration between P-HEMS, EMS and DC, (3) handover between EMS and P-HEMS and (4) a minimal adequate prehospital trauma handover. Table 3 shows the degree of consensus or non-consensus per topic and statement for the second round. When we look at how individual parameters are to be reported in a minimal adequate prehospital trauma handover, 93% agrees on an estimation of the age when the exact age is unknown (Y+). There is no consensus on the usage of the GCS or AVPU model to report on patient's neurological status (N), though 88% agrees that loss of consciousness should be reported (Y+). Ninety-nine percent agreed on the importance of reporting a clear, obstructed or potentially obstructed airway (Y+), though there is no consensus on reporting the exact breathing frequency (N). However there is consensus on the importance of giving an interpretation of the breathing frequency (72%, Y+). There is no consensus on reporting the oxygen saturation or the character of the breathing sounds (N). Likewise there is no consensus on reporting the exact heart rate (N), though there is consensus on the importance of giving an interpretation of the heart rate (79%, Y+). There is no consensus on the importance of reporting the exact blood pressure (N), however there is consensus on the importance of reporting on the most peripheral pulse palpable and its character (75%, Y+), but not on the exact frequency (N). There is consensus on the importance of reporting visible blood loss (79%, Y+), however there is no consensus on reporting this in an estimate of volume loss (N). Eighty-one percent agrees on the importance of reporting the given treatment (Y+). There is no consensus on reporting on the treatment plans (N).

Table 3. Consensus per statement and topic for round 2

Topic	N	Statement	N	%	Consensus
P-HEMS dispatch	1	When "ABCD" stable is reported this means, one can aspect no deterioration.	70	77	Y-
	2	When no deterioration is to be suspected, the care of a P-HEMS is not needed.	70	46	N
	3	Dispatching a P-HEMS for adequate analgesia is justified.	70	83	Y+
	4	It is justified to accept an incomplete MIST-handover	70	64	T+
	5	Assessing the ABCD status of a patient by a professional does not take longer than one or two minutes	70	71	Y+
	6	Due to differences in interpretation it is better to discard terms such as SR and SP or "ABCD-stable" in order to prevent communication errors	70	56	T+
	7	It would be useful to incorporate a RTS-score chart in the prehospital setting.	70	37	N
	8	When an RTS-score chart would be available, I would use this	70	40	N
	9	It would be of additive value to incorporate a GCS-score chart in the prehospital setting	70	49	N
	10	When a GCS-score chart would be available, I would use this	70	49	N
	11	There is a set method for prehospital handover between EMS and P-HEMS: the MIST method	70	61	T+
	12	There is a set method for prehospital handover between EMS and P-HEMS: the SBAR method	70	36	N
	13	There is no set method for prehospital handover between EMS and P-HEMS.	70	63	T-
	14	there is need for a set method for prehospital handover between EMS and P-HEMS	70	69	T+
Collabo-ration EMS	1	the importance of integration of the training for the different EMS	67	85	Y+
	2	on the importance of multidisciplinary training	67	92	Y+
	3	evaluation of care via integrated care meetings	67	100	Y+
	4	all EMS should be aware of the protocols of the other involved EMS	67	86	Y+

Topic	N	Statement	N	%	Consensus
Handover	1	that reporting “ABCD” stable is to brief for an MAPH	67	76	Y+
	2	it is useful to determine the content of a MAPH	67	91	Y+
	3	a MAPH is a handover on which the person who the information is handed to can make an educated estimation of the situation, the patient and the course	67	94	Y+
	4	a MAPH should help EMS make educated decisions in a short period of time	67	90	Y+
	5	When consensus is reached on the structure and content of a MAPH this should be included in all EMS protocols	67	90	Y+
	6	that using a MAPH is important for the communication between ambulances, dispatch centers, P-HEMS, other EMS and the receiving hospital	67	87	Y+
	7	usage of a MAPH will help facilitate the transfer/or acceptance of responsibility of care	67	87	Y+
	8	usage of a MAPH may aid in improving prehospital trauma patient care	67	90	Y+
MAPH	1	information regarding gender should be incorporated into a MAPH	67	70	Y+
	2	information regarding age should be incorporated into a MAPH	67	97	Y+
	3	information regarding MOI should be incorporated into a MAPH	67	96	Y+
	4	information regarding injuries sustained should be incorporated into a MAPH	67	96	Y+
	5	information regarding patients airway should be incorporated into a MAPH	67	99	Y+
	6	information regarding patients breathing should be incorporated MAPH	67	97	Y+
	7	information regarding hemodynamic status should be incorporated into a MAPH	67	97	Y+
	8	information regarding neurological status should be incorporated into a MAPH	67	99	Y+
	9	information regarding neurological abnormalities should be incorporated into a MAPH	67	90	Y+
	10	information regarding medical history should be incorporated into a MAPH	67	52	T+
	11	information regarding medicine usage should be incorporated into a MAPH	67	51	T+

P-HEMS: Helicopter Emergency Medical Services, MIST: Mechanism of injury, injuries found and suspected, vital Signs and treatment given, MAPH: Minimal adequate prehospital handover, RTS: Revised Trauma Score, GCS: Glasgow Coma Scale, EMS: Emergency Medical Services, MOI: Mechanism Of Injury, N= Nonconsensus, T+ Tendency to agreement T-: tendency to disagreement, Y+ consensus on agreement, Y-: consensus on disagreement

Round 3

In order to generate consensus on the exact content of a 'minimal adequate prehospital trauma' handover statements were presented along with background information, argumentation form the previous round and argumentation from the SC. One hundred twenty panelists were contacted of which 64 participated. Nineteen respondents were P-HEMS-physicians, six P-HEMS-nurses, 24 EMS personnel, eight dispatch operators and 14 trauma surgeons. There was an agreement on using the AVPU scale as a prehospital mode of reporting on the neurological status of the patient in a minimal adequate handover (78%, Y+). There was no agreement on discarding information on patient's medical history from a minimal adequate handover (N). There is tendency to agreement on discarding information on patient's medicine usage from a minimal adequate handover (68%, T+). There was an agreement on discarding information on the exact breathing frequency (measured in breaths per minute) and instead giving an impression of the breathing frequency in a minimal adequate handover (81%, Y+). There is agreement on discarding information on the character of the breathing sounds from a minimal adequate handover (83%, Y+). There is a tendency to agreement on discarding information on the exact heart rate (measured in beats per minute) and instead giving an impression of the heart rate in a minimal adequate handover (63%, T+). There is a tendency to agreement on discarding the exact blood pressure (measured in mmHg) and instead giving an impression of the blood pressure (most peripheral pulse palpable and its character) in a minimal adequate handover (61%, T+). There is a tendency to agreement on discarding information on the treatment plan form the minimal adequate handover (68%, T+).

DISCUSSION

We describe a modified Delphi study on the consensus of the content of a minimal adequate prehospital trauma handover. The process comprised an extensive literature review followed by a three round survey. This was executed among a national representative panel of experts in the field of prehospital and in hospital trauma care. We consider it useful because consensus on a set of parameters describing the optimal combination for a minimal adequate prehospital handover between EMS, P-HEMS and the receiving hospital was achieved. This allows for the prehospital communication to be more precise, adding in the optimization of trauma care. Of the 120 invited panelist 67 (58%) completed all three rounds, this is a high number when looking at international literature, providing an effective and reliable sample to allow for effective decision-making [17]. The initial research question was: which trauma patient deserves the advanced care of P-HEMS? Due to complexity of the issues raised, we were not able to answer this question yet, however by focusing on communication, a factor of paramount influence; we aimed to gain more insight. As is stated by the expert panel, "in order to improve prehospital trauma care it is vital to improve the prehospital communications between all EMS". When prehospital communication has become more transparent and uniform, this will aid in recording more detailed prehospital information which in turn will hopefully allow further research into factors that identifying major trauma patients can be done. Prehospital trauma care often involves hurried interactions between individuals with varying styles of communication, furthermore this communication; is often incomplete [18]. A standardized approach to information sharing is needed, to ensure that patient information is consistently and accurately. This will allow for accurate assessment of the type of care needed and the responsibility of care, it will reduce over and under triage and improved utility of in hospital trauma teams. Appropriate method of handover may prevent errors, adverse events and avoid patient harm [19,20 and 21]. The DENIM parameters are a more detailed set parameters than those currently used in the SBAR or MIST method [22, 23, and 24]. They can be used by all EMS to ensure the quality of handing over in the prehospital setting. The some of the DENIM parameters are in accordance with the IMIST-AMBO, which shows promise for improving the ambulance to emergency room handover communication [25]. Implementation of this tool let to a greater volume of information per handover, reduction of handover and improved recipient comprehension. This will likewise be tested for the DENIM model in a feasibility study.

A limitation of this study is the qualitative design, often it is thought that studies based on expert opinion rank low in scientific evidence [26]. The additive value of the communication tool developed by experts within the field needs to be further investigated in a prospective matter. A second limitation is that this was a Dutch national survey, focusing on elements typical for Dutch prehospital trauma care (such as high density of hospitals, short transport distances and time, nurse staffed EMS and both nurse and physician staffed P-HEMS). However, the Dutch trauma system operates according to international standards and the nurses and physicians are trained according to international guidelines. Therefor our findings might be applicable to other prehospital trauma setting who use a similar structure and have a similar chain of deployment of the EMS and P-HEMS. From the DENIM several conclusions can be drawn. First the respondents reported that it is difficult to define what ABCD-stable means and that reporting ABCD-stable is insufficient for a prehospital handover between EMS and P-HEMS. Many respondents also reported that it is sometimes difficult to assess if the responsibility of care lays with the EMS or P-HEMS and that it is critical to communicate properly to transfer this responsibility or to make an assessment by the P-HEMS physician that their care is not necessary and keep the responsibility of care with the EMS. It was also stated that the interpretation of the neurological status, as well as other parameters, can be quite challenging and may be different for every EMS of P-HEMS physician. Therefore it was said that strict regulation should be implemented and that all EMS should follow these regarding the interpretation of for instance EMV or RTS. Furthermore it was stated that some of the currently used scoring systems are too difficult or unpractical to use. What can be seen from the statements is that there is a wide variation in interpretation of the definition of terms used in the prehospital setting such as Scoop&Run and Stay&Play, which can lead to different treatments for the same cases. The respondents agreed that a dispatch of the

P-HEMS based on severe mechanisms of trauma and injuries sustained is acceptable, and that the additive value of the P-HEMS is mostly in stabilizing the ABC of a trauma patient. It is often said that for continuing or cancelling the P-HEMS the prehospital logistics and time to the nearest trauma center is very important. It was stated by the respondents that the dispatch frequency varies per dispatch center mainly due to a difference in culture but also due to unawareness of the possibilities of the P-HEMS. Respondents tend to dispatch P-HEMS with a lower threshold when it concerns young children or elderly patients. Or when it concerns a trauma mechanism to which the EMS ambulance has low exposure. Furthermore one can conclude reporting ABCD-stable does not necessary means no deterioration is to be expected. Dispatch the P-HEMS for advanced analgesia is accepted by the respondents. It was agreed that there is no method for handing over in the prehospital setting and the usage of both MIST, SBAR and ABCD are opted. There is agreement on the need for a set method for a prehospital handover. Likewise the respondents agreed it is important that there should be more multidisciplinary training, schooling and evaluation of care. The respondents found it useful to determine the content of a minimal prehospital handover, which should be implemented in all EMS protocols when consensus has been reached. There is consensus that information regarding gender, age, MOI, injuries sustained, the patient’s airway, breathing, hemodynamic status and neurological status and neurological abnormalities should be reported in a minimal adequate prehospital handover. There was agreement or minimally a tendency to agreement on the exact content of how to report the parameters in a minimal adequate prehospital trauma handover.

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Submitted

Chapter 7

DENIM communication tool for prehospital trauma handover: a national consensus

ABSTRACT

Introduction

Prehospital trauma care is integrated care. Especially trauma care for the severely injured. Several types of Emergency Medical Services (EMS) can be dispatched simultaneously. The dispatch center needs to work closely with all EMS to orchestrate proper flow of medical resources. Furthermore all EMS communicate between themselves to ensure proper medical care. Accurate communication and especially the method of handing over is critical for decision making and transfer reliability of care. The aim of the DENIM study (a Delphi-procedure on the identification of prehospital trauma patients in need of care by Mobile Medical Teams) was to assess which information was deemed critical for proper situational assessment and generate a consensus-based communication tool for prehospital trauma handover.

Methods

A three round digital Delphi study was performed to explore concepts in prehospital communication. P-HEMS physicians/nurses, trauma surgeons, EMS paramedics and emergency medical operators where asked to state their opinion regarding factors influencing prehospital communication and which information is deemed critical for proper hand-over. Statements were presented and panelists were asked to if they agree or disagree to the statement, using either a five-point Likert scale (totally agree, agree, neutral, disagree, totally disagree) or a three-point Likert scale (agree, neutral, disagree). Results of the previous rounds were feedback to the panelist in order for them to revise their opinion and converge toward group consensus.

Results

Sixty-four panelists completed all three rounds. From the first round four principle themes arose: factors that influence prehospital communication, critical information for proper handover, factors influencing collaboration and how training/education can influence this. The second round focused on what type of information was deemed essential for good situational awareness and therefore handover. The third round focused on determining the exact content of a minimal prehospital trauma handover. The majority of the experts agreed to a set of ten parameters creating a new method for handover in the prehospital setting.

Conclusion

The DENIM study presents a new prehospital communication model, based on national consensus amongst experts in the field of prehospital trauma care. The model comprises of a set of 10 parameters to aid EMS and P-HEMS to structure the handover and provide each other with the essential information to create appropriate situational awareness.

INTRODUCTION

From the DENIM study on can see that communication and methods for handing over appear to be a factor of influence on prehospital collaboration and are though to influence trauma patient outcome [1]. A handover refers to the transfer of professional responsibility and accountability for some or all aspects of care for a patient, or a group of patients, to another professional or group of processionals [2]. It is recognized as an important source of error thus a unique opportunity to optimize patient safety. Prehospital trauma life support is a multidisciplinary type of care. The dispatch center primarily dispatches Emergency Medical Services (EMS) [3,4]. Depending on the type of distress call the dispatch center can furthermore dispatch the fire brigade, police, physician staffed helicopter emergency medical services (P-HEMS), environmental services or even the disaster taskforce [5]. When a severe accident occurs with multiple severely injured patients, numerous disciplines work together making prehospital trauma care for the severely injured patient integrated care. The prehospital communication between the dispatch center and all types of EMS is done via the C2000. A national communication system which can be used 24x7 by all EMS (police, fire brigade, ambulance services, dispatch centers, the Ministry of Defense and the Royal Military Police) [6]. Accurate communication is vital in integrated care and especially in prehospital trauma care, which is often performed in hectic situations. EMS are required to make decisions rapidly and in most cases under pressure [7]. In order to ensure accurate formation of situational awareness, information deemed critical for handover needs to be identified. Accurate situational awareness is vital for decision making and depends on a good information flow, often from multiple sources [8]. Decisions based on low grade information can lead to poor patient outcome and/or risk to EMS [7,9]. Seppänen et al. show that factors influencing inadequate information flow are amongst others: information gaps, lack of fluent communication and lack of a common operation tool [8]. A previous study on prehospital communication between EMS and P-HEMS showed that prehospital trauma handovers are often sparse in information [10]. Merely 16% of all handovers entailed a complete situational report. Furthermore, several different methods for handing over were used or even no structured method was used. An international study likewise shows that to ensure patient safety, continuity of care is key and that an adequate information transfer is more efficient when a handover is done in a structured fashion [11]. In the Netherlands the EMS nurses are supposed to handover to the Emergency Department (ED) personnel using the MIST acronym (Mechanism, Injury, Symptoms and Treatment) [4,12]. However this method of handing over does not always cover everything and it is not used by all additional services. Several other known methods for handing over exist e.g. The Situation, Background, Assessment and Recommendation (SBAR) technique [13], The Subjective, Objective, Assessment, Plan (SOAP), or the Mechanism/medical complaint, Injuries/information relative to the complaint, Signs, vitals and GCS, Treatment and trends/response to treatment, Allergies, Medications, Background history and Other (social) information (IMIST-AMBO) [14,15]. The SBAR is cited most frequently. A study by Ilan et al. showed a wide range of usage in different handover methods and that critical care physicians did not conform to any of the predefined methods [16]. Also, it appeared from the DENIM study

(a Delphi-procedure on the identification of prehospital trauma patients in need of care by Mobile Medical Teams) that consensus was needed on the method and content of the handover to improve care [17].
The aim was to assess the type of critical information that EMS need in order to make a proper situational assessment, to identify which type of patient is in need of the additional care of P-HEMS, generating an expert based standard for identifying the critically injured patient. Furthermore, this generates a consensus-based communication tool for handing over for prehospital trauma patient. The tool was build using the DENIM study [17]. This paper is a part of a wider investigation on how to improve prehospital trauma care for the severely injured. The aim of this paper is to present a consensus-based communication tool for the handover on a prehospital trauma patient.

METHODS

The Delphi technique was used for the DENIM study. A detailed protocol and partial results of the DENIM study have been published previously [17,1]. In brief, the DENIM study is a national three round online questionnaire to generate consensus generation amongst a group of experts [18,19]. The responses are analyzed after each round and fed back in an anonymous matter prior to the next round. Allowing the panelist to revise their opinions and converge to an average group opinion [20]. The DENIM Steering Committee (SC), which comprises of members from the department of trauma surgery, anesthesiology and from P-HEMS, and extended by a member with experience in performing Delphi studies. The SC constructed the questionnaires, prepared, analyzed, supervised and monitored all Delphi round. The DENIM respondents were professionals within the Dutch field of pre- and in hospital trauma care (P-HEMS physicians and nurses, trauma surgeons, EMS personnel and emergency medical operators) and divided across the country minimizing bias due to local culture and geographical factor.
The first DENIM round the main question was; which trauma patient would benefit from the advanced care of P-HEMS? A detailed overview of other results of DENIM study can be found in the result study [1]. After the first Delphi round it appeared that first consensus needs to be reached on the content of communication and/or communication structure. Therefore the second round focused on factors influencing prehospital communication, what information is deemed critical for proper handover, what factors influence collaboration and how can these can be influenced from a training/educational perspective? From here-on the third round was done to exactly establish the content of a prehospital handover. During all three DENIM rounds several types of questions are presented to the panelists. In the first round open cases were presented and panelists had to stated there opinion in an open text box. Furthermore, statements were presented and panelists were asked to if they agree or disagree to the statement, using either a five-point Likert scale (totally agree, agree, neutral, disagree, totally disagree) or a three-point Likert scale (agree, neutral, disagree).

Data analysis

A two stage qualitative thematic analysis was undertaken, to analyze the results of the first round [21]. Two authors assessed the results independently and identified broad coding themes. These were discussed and agreed by the entire SC. Quantitative data was entered into the SPSS statistical software package version 22 and analyzed to examine level of agreement. Answers were analyzed using descriptive statistics. When at least 70% of the experts either agreed or disagreed this was considered consensus. Percentage between 55% and 70% was considered as tendencies towards consensus and all statements that scored below 55% was considered non-consensus. Table 1 shows all possible outcomes of consensus. Ethical approval for this study was granted by the Medical Ethics Review Committee of the VU University Medical Center.

Table 1. Possible group outcome for the statements

Answers	Group	Symbol
> 70% Of the respondents agrees with the statement presented.	Consensus to agreement	Y+
> 70% Of the respondents disagrees with the statement presented	Consensus to disagreement	Y-
55-70% Of the respondents agrees with the statement presented	Tendency to agreement	T+
55-70% Of the respondents disagrees with the statement presented	Tendency to disagreement	T-
Everything <55% for agreement and disagreement	Non-consensus	N

RESULTS

For this study 120 panelists were contacted to participate.

Round 1.

In the first round 81 panelists participated. Twenty-one P-HEMS physicians, eleven P-HEMS nurses, 28 EMS nurses, fourteen dispatch center operators and 22 trauma surgeons. All regional EMS services and all P-HEMS teams were equally represented. Nine out of the eleven trauma centers were represented.

Round 2.

In the second round 79 panelists participated, of whom eleven (11.54%) panelists were dispatch center operators, 27 (34.62%) EMS nurses, eight (10.26%) P-HEMS nurses, sixteen (20.51%) P-HEMS physicians, 24 (30.77%) trauma surgeons.

Round 3.

In the third round 64 panelists participated of whom eight (12.50%) were dispatch center operators, 24 (37.50%) EMS nurses, six (9.38%) P-HEMS nurses, 19 (29.69%) P-HEMS physicians and fourteen (21.88%) trauma surgeons.
Through the second and the third round the several occupations were represented equally, as were the regional EMS services, the P-HEMS teams and the trauma centers.

From all three DENIM rounds one could construct a new model for handing over (figure 2). And Table 2 presents an overview of consensus on the statements per component of the tool for the first and second DENIM round. Main arguments for these results were:

Figure 2. New model for prehospital trauma handover

1.	Male / Female
2.	Child / Adult
3.	MOI
4.	Injuries
5.	A: Free / Potentially threatened / Threatened
6.	B: Bradypnea / Eupnea / Tachypnea
7.	C: Bradycardia / Normocardia / Tachycardia Peripheral pulse Blood Loss
8.	D: Loss of consciousness AVPU Neurological deviations (pupillary defects, lateralization, open brain injury)
9.	Given treatment
10.	Relevant medical history

MOI: Mechanism of injury, AVPU: alert, verbal, pain, unresponsive

Table 2. consensus per topic

Topic	Statement	N	%	consensus
Gender	It is of importance to state the gender of the patient in a MAPH	70	70	Y+
Age	It is important to include information on the age of the patient in a MAPH	67	97	Y+
	When the exact age of the patient is unknown, it will suffice giving an estimation of the age in a MAPH	67	93	Y+
MOI	It is important to give a short report of the mechanism of injury in a MAPH	67	96	Y+
Injuries	It is important that a short report of the apparent injuries is reported in a MAPH	67	96	Y+
Airway	It is important to give information on the airway of the patient in a MAPH	67	99	Y+
	It is important to report if the patient's airway is sufficient, potentially insufficient or insufficient in a MAPH	67	99	Y+
Breathing	It is important to include information on the patients breathing in a MAPH	67	97	Y+
	It is important to report the exact breathing frequency of the patient in a MAPH	67	54	N
	When the exact breathing frequency is unknown, it is important to include an estimation of the frequency in the form of: bradypnea / eupnea / tachypnea in a MAPH	67	72	Y+
	It is important to include information on blood oxygen saturation levels in a MAPH	67	60	T+
	It is important to include information on the character of the breathing sounds in a MAPH	67	49	N
Circulation	It is important to include information on the circulatory status of patients in a MAPH	67	99	Y+
	It is important to include the exact heart rate in a MAPH	67	57	T+
	When the exact hart rate is not known, it is important to include an estimation of the heart rate in a MAPH in the form of: bradycardia / normocardia / tachycardia	67	79	Y+
	It is important to include the exact blood pressure of the patients in a MAPH	67	52	N
	It is important give an impression of the blood pressure by reporting on the most peripheral pulse palpable, its location and its character (e.g. strong/weak) in a MAPH	67	75	Y+
	It is important to include the exact frequency of the peripheral pulse in a MAPH	67	51	N
	It is important to report on visible blood loss in a minimal adequate handover	67	79	Y+
	When blood loss is reported it is important to give an estimation of the volume lost in a MAPH	67	51	N

Topic	Statement	N	%	consensus
Disability	Is the AVPU a correct method for a neurologic situational report?	81	51	N
	It is important to include information on the patient's level of consciousness in a MAPH	67	99	Y+
	It is important to include information on the patient's level of consciousness in the form of one of the following methods. Choose the method that suits your preference: GCS, AVPU, conscious/ unconscious	67	90	Y+
	It is important to report when the patient has experienced loss of consciousness in a MAPH	67	88	Y+
Treatment	It is important to include information on the given treatment in a MAPH	67	81	Y+
	It is important to include information on the treatment plan in a MAPH	67	51	N
Medical history	It is important to include information on the patients' medical history in a MAPH	67	52	N
Medicine use	It is important to include information on the patient's medicine usage in a minimal adequate handover	67	51	N

MAPH: minimal adequate prehospital handover, MOI: mechanism of injury, AVPU: acronym for Alert, Verbal, Pain, unresponsive, GCS: Glasgow coma scale

Gender

In round two the respondents report it is important to state the gender in a Minimal adequate prehospital handover (MAPH) because of the physiological differences and also different reaction to medication, risk of thrombosis and pregnancy.

Age

In round two the respondents report it is important to include information on the age of the patient in a MAPH because of the physiology changes with increasing age. Elderly patients have less reserves and are often less able to compensate in situations of hemodynamic instability. Furthermore, several scores used are different for different ages. For instance the regular Glasgow Coma Scale (GCS) does not apply to children. Though it is opted that the exact age does not need to be known and estimation or a category into what the patients belong would suffice.

Mechanism of Injury (MOI)

In round two the respondents report it is important to give a short report of the mechanism of injury in a MAPH because it gives insight in possible transfer of energy and therefore the injuries sustained. However it is also stated that the reports of bystanders are often inaccurate. Furthermore it is stated that this information should be seen in light of other patient information. For instance a fall of same height could be detrimental for an elderly patient using anti-coagulants but not for a younger healthy person. However it is also stated that based on the MOI a good estimation of the needed care can be done.

Injuries

In round two the respondents report it is important that a short report of the apparent injuries is reported in a MAPH because the injuries often influence the treatment given in the prehospital setting. Though it does increase reporting time. Some state that only the significant injuries that may influence patient´s vital signs should be reported.

Airway

In round two the respondents report it is important to give information on the airway of a patient in a MAPH and to report if a patient's airway is sufficient, potentially insufficient or insufficient. Because EMS nurses are not always able to make a proper estimation of a patient's airway, especially in the case of children. This information is also of value in the report to the receiving hospital, to activate the proper trauma team. Though, it is also stated that this information should be accompanied with information regarding the neurological status of the patient. Furthermore, it is stated that only deviations of normal should be reported in a MAPH.

Breathing

In round two the respondents report it is important to include information on patients breathing in a MAPH. There is no consensus on reporting the exact breathing frequency. Main argument was that an interpretation of the frequency should be sufficient, that it takes time to calculate the breathing frequency per minute. Reasoning for reporting the exact frequency is that it is a part of the early warning score. It is also stated that only deviations from normal should be handed over. Furthermore it is stated that an estimation of the frequency may also be given when the exact frequency is unknown. Furthermore there is no consensus on including information on blood oxygen saturation levels. Arguments raised are that it is often difficult to measure in the prehospital setting due to cold and peripheral vasoconstriction. This information should be combined with information regarding pulmonary medical history. The blood oxygen saturation levels are not a proper reflection of the actual saturation status. Likewise, there is no consensus on reporting on the character of the breathing sounds. Main reasoning is that this should only be reported when absent. However it is likewise said that many EMS nurses have too little knowledge/experience to make an adequate estimation of the situation. It is furthermore stated that it is a timely effort.

In the third round the following statements regarding breathing of the patient were presented:

- "In the second round of the DENIM study there was no consensus on reporting the exact breathing frequency in a minimal adequate handover. Reasoning for reporting the exact frequency is that it is a part of the early warning score. Arguments against reporting the exact frequency are: that a global estimation is sufficient, it is difficult to measure in the prehospital setting, it takes time to measure, an impression of the frequency gives enough information, in stressful situations all patients tend to have an elevated breathing frequency. Consensus was reached on reporting an impression of the breathing frequency in a minimal adequate handover. In light of al before mentioned we would like to opt not to use the exact breathing frequency in a prehospital trauma handover but to report an impression of the frequency in the form of: bradypnea / eupnea / tachypnea. Do you agree with this method for reporting?". There is consensus to agreement (81.25% agrees, 18.75% disagrees).
- In the second round of the DENIM study there was no consensus on reporting on the character of the breathing sounds in a minimal adequate handover. There were no argument in favor of reporting on this. Arguments against reporting were: it is only of additional value when it is deviated, it is time consuming and there is too little knowledge amongst EMS nurses to make a reliable interpretation. "In light of all before mentioned we would like to opt not to report on the character of the breathing sounds in a prehospital trauma handover. Do you agree with this method for reporting?". There is consensus to agreement (82.81% agrees, 17.19% disagrees).

Circulation

In round two the respondents report it is important to include information on the circulatory status of patients in a MAPH. There is no consensus on including the exact heart rate. Though there is consensus on reporting giving an estimation of the heart rate in the form of: bradycardia / normocardia / tachycardia. There is no consensus on reporting the exact blood pressure, however there is consensus on reporting an impression of the blood pressure by reporting on the most peripheral pulse palpable, its location and its character (e.g. strong/weak) in a minimal adequate handover. There is no consensus on reporting the exact frequency of the peripheral pulse. There is consensus on reporting visible blood loss, though there is no consensus on reporting an estimation of the volume of blood lost.

In the third round the following statements regarding the circulation of the patient were presented:

- "In the second round of the DENIM study there was no consensus on reporting the exact heart rate in a minimal adequate handover. Arguments in favor of reporting the exact frequency were not given. Argument against were: it is important to measure, however an estimation of the frequency will provide enough information, it takes too much time to determine the exact frequency and the heart rate is often elevated due to stress. Consensus was reached on reporting an estimation of the heart rate in a minimal adequate handover. In light of all before mentioned, we would like to opt not to use the exact heart rate in a prehospital trauma handover but to report an impression of the heart rate in the form of:

bradycardia / normocardia / tachycardia. Do you agree with this method for reporting?". There is tendency to agreement (62.50% agrees, 37.50% disagrees).
"In the second round of the DENIM study there was no consensus on reporting the blood pressure in a minimal adequate handover. Arguments in favor of reporting the exact blood pressure were not given. Arguments against were: due to clothing this is often difficult to measure in the prehospital setting, feeling a peripheral pulse gives enough information on circulation. There was consensus on reporting an impression of the blood pressure. In light of all before mentioned we would like to opt not to report the exact blood pressure but an estimation of the blood pressure by reporting on the most peripheral pulse palpable, its location and its character (e.g. strong/weak) in a minimal adequate handover". Do you agree with this method for reporting?". There is tendency to agreement (60.94% agrees, 39.06% disagrees).

Disability

In round one and two the respondents report no consensus on whether or not the AVPU (acronym for: alert, verbal, pain, unresponsive) is a correct method for a neurologic situational report. There is consensus on including information on the patient's level of consciousness and any neurological deviations in a minimal adequate handover. There is no consensus on what method to use for reporting the level of consciousness. There is consensus reporting any experienced loss of consciousness.
In the third round the following statement regarding the neurological status of the patient was presented:
- "In the second round of the DENIM study there was no consensus on reporting on the consciousness in a minimal adequate handover. One was asked to choose between: GCS, AVPU, conscious/unconscious. Arguments in favor of usage of the GCS were amongst others: that the GCS gives plenty information, is reliable, has several degrees allowing better monitoring of deterioration and/or improvement. Arguments for the usage of the AVPU method were: easier to score than GCS, it gives a quick insight in the patient's neurological status, it is more reliable than the GCS in the prehospital setting, GCS is in some cases too difficult to score, the GCS can be scored in retrospect, AVPU is more practical. In light of all before mentioned and because it is essential to determine a set method for reporting on a patient's neurological status we would opt to use the AVPU in a minimal adequate handover. Do you agree with this method for reporting?". There is consensus to agreement (78.13% agrees, 21.88% disagrees).

Treatment

In round two the respondents report consensus on including information on the given treatment though, there is no consensus on reporting the treatment plan.
In the third round the following statement regarding the treatment of the patient was presented:
- "In the second round of the DENIM study there was no consensus on reporting on the

treatment plan in a minimal adequate handover. Arguments in favor were: that the P-HEMS team can aid in information. Arguments against were that the EMS crew remains head of treatment and therefore remains in charge of the treatment plan, it also takes more time to report and is considered not of additive value. In light of all the before mentioned, we opt not to report on the treatment plan in a minimal adequate handover. Do you agree with this?". There is consensus to agreement (67.19% agrees, 32.81 disagrees).

Medical history

In round two the respondents report no consensus to include information on the patients' medical history.
In the third round the following statement regarding the medical history of the patient was presented: "In the second round of the DENIM study there was no consensus on the medical history in a minimal adequate handover. Arguments in favor of reporting the medical history were amongst others: it gives good insight if the parameters measured match the patient. Only relevant medical history should be mentioned. However what this relevant medical history is, apart from pregnancy, is not reported. Arguments against reporting the medical history are amongst others: this information is often not available in the prehospital setting, it is often not in relationship to the complaints/injuries sustained and trying to get information on medical history in the prehospital setting can cause delay. In light of all before mentioned we opt not to report the medical history in a minimal adequate handover. Do you agree with this?". There is no consensus to agreement (53.13% agrees, 46.88% disagrees).

Medicine use

In round two the respondents report no consensus to include information on the patients' medicine usage.
In the third round the following statement regarding the medicine usage of the patient was presented:
- "In the second round of the DENIM study there was no consensus on reporting the medicine use in a minimal adequate handover. There were no arguments in favor of reporting the medicine use, it was however specified that relevant medication should be reported amongst others: anticoagulants, antihypertension, anti-psychotic and anti-epileptic medicine. Arguments against reporting on the medicine use were that this information is often not available in the prehospital setting, that it takes a lot of time to get this info clear, that is does not change primary trauma care policy. However it is frequently stated that this is different for the usage of anti-coagulants. In light of all before mentioned we opt not to report the medicine use in a minimal adequate handover. Do you agree with this?". There is a tendency to consensus (68.75% agrees, 31.25% disagrees).

In round two the respondents were furthermore questioned about the use of the current acronyms for handing over, this is shown in appendix 4.

DISCUSSION

This study used the Delphi method to develop guidelines for handing over in a prehospital trauma setting. Overall, a set of ten parameters were endorsed by the respondents and consensus on how to report on these parameters was reached. The endorsed parameters were put into a model creating a new short and practical model for handing over. It is important to provide EMS and P-HEMS personnel with a structured handover model, because this ensures expedient and appropriate care [22]. This model will be presented in a guideline document which all Dutch prehospital and in hospital trauma care organizations can access. This document provides background as to how the model was derived. Furthermore, instructions on how to use the model are likewise given. There are guidelines on how to report in a prehospital setting [14,23-25]. There is some overlap in parameters reported. For example, in the SBAR method "the situation" is to be reported, we found this term to be to generalistic, therefore we ask to report the mechanism of injury [13]. Giving EMS nurses guidelines on what exactly to report regarding situation. Furthermore in the SBAR method one is asked to report on the "Assessment", one should report on the "signs and symptoms" as well as "treatment" in this section. This again is a general term, not elaborating on what is to be reported exactly. Therefore the DENIM created a communication tool for prehospital handover on trauma patients, establishing a guideline on what to report on patient's vital signs and injuries as well as the treatment. Furthermore the method of reporting is defined. When one compares the DENIM tool to the MIST method, similarities are: reporting the mechanism of injury and the injuries sustained. However as for the SBAR method, the MIST method asks to report on vital signs and treatment in a very generalistic manner [14] leaving it open to interpretation what should actually be handed over. For this study the challenge was to develop a communication tool specific enough to be valuable, while still being practical to be managed in the prehospital setting and to be applicable across the various types of trauma.

Of the ten parameters adopted in the tool, there were five that generated many differences in opinion and commentary from the panelists. Firstly the assessment of the neurological status created much debate. In the feedback it is often reported that usage of the GCS is difficult, that not everyone feels capable using the GCS and that there are many other factors that may influence neurological status such as intoxication which do not need to be detrimental. Furthermore it is often questioned if the GCS is correctly calculated and that the cut-off values should be used as guidelines not as set rule. It was rejected to use the GCS in the prehospital trauma handover and instead the AVPU-scale was preferred. The AVPU scale is a more practical system, giving enough detail on the level of consciousness whilst guarding time management.

The second theme that raised much debate was the method for reporting on the breathing status of the patient. It was frequently stated to be of vital importance to include information on breathing. However, many EMS-nurses find the exact breathing frequency to be unworkable to report, same applies to the heart rate. Instead it is often opted that an impression of the frequencies should provide both EMS and P-HEMS with enough information to create a proper situational assessment of the trauma patient. This was likewise the discussion for the measurement of the blood pressure. It is thought that by reporting the most peripheral pulse palpable one can adequately assess the patients circulatory status, mainly because the handovers are done in hectic time critical situations and need to be performed quickly. The fourth topic of debate was if the given treatment should be reported, mainly because this takes time. However it was often reported to be such vital information for the interpretation of the development of the patient's vital parameters that this should be adopted in the handover. Finally the panelists found it difficult to reach consensus as to whether or not a patient's medical history should be reported. Arguments raised where that it is often not of significant value. However some things are, though it is not possible to log what should and should not be reported. It is also stated that medical history or medicine use is often unknown. The new handover model is complementary in that it should always be an addition to the information the EMS nurse thinks is essential to handover. This study has several strong points. In the first place the heterogeneity of the panel, all the disciplines involved in prehospital trauma care are represented [26]. The second strength is the panel size, in the first round 81 completed the questionnaire, in the second round 79 completed the questionnaire and in the end 64 out of the 120 panelists completed all three rounds [27-30]. Furthermore heterogeneity is ensured amongst the different trauma centers, the regional EMS services and all P-HEMS teams were represented. Though this is a Dutch survey we think that this method for handing over can be adopted in any international trauma system since there are similarities with other foreign countries with regard to team composition and triage structure [31]. Methods used in this study followed the structure as previously used and published [29,30,32,33]. The validity of including specific parameters in the questionnaires and the communication tool can be criticized; however, this has no impact on the comparative importance that experts place on such parameters. Inherent danger is that the anonymity of the study leads to a lack of accountability for the expressed views. Another limitation is that the findings may be biased due to the used methodology. By structuring the questionnaire in a certain manner participants may be steered into a direction. We aimed to minimize this effect by making the open argumentation in the textbox comments obligatory. Although this still may have induced the prioritization of some parameters over others. Correspondingly, the order in which the parameters were presented within the questionnaires may have had an impact on responses. Further research is needed to understand the implications of this study. This study helped to identify parameters that the experts within the field of prehospital trauma care deemed critical to handover. Findings of this Delphi may help to streamline prehospital communication, however it is important to note that the existence of consensus does not mean that the correct answer, opinion or method for handing over has been found.

CONCLUSIONS

The purpose of this study was improving prehospital communication generating consensus on the exact content of a minimal adequate prehospital handover for a trauma patient. This study presents a new communication model, based on 10 parameters on which consensus was reached. To aid EMS and P-HEMS to structure the handover and provide each other with the essential information to create appropriate situational awareness. The DENIM communication tool is thought to be practical and user friendly while covering the minimal necessary content as deemed critical for handover by the DENIM national respondents panel.

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Part 3

In hospital trauma care for the severely injured

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Chapter 8

Optimization of trauma care: a two-tiered in hospital trauma team response system.

ABSTRACT

INTRODUCTION

To improve utilization of resources and reduce over triage, a two-tiered trauma team activation (TTA) system was implemented. The system activates a complete or selective trauma team (CTT, STT). Activation is based on mechanism of injury (MOI), prehospital vital signs and injuries. The objective was to evaluate the feasibility, effectiveness and safety of the implementation of a two-tiered system and whether triage is done according to the TTA criteria.

METHOD

A prospective observational study was performed at the emergency department of a Level I trauma center. Data were collected on TTA criteria, patient demographics, MOI, prehospital vital signs, imaging modalities and blood gas analysis in the emergency department and in hospital data.

RESULTS

In three months 186 patients were presented to the trauma resuscitation room. Thirty-four patients were excluded, 152 patients were included for analysis. Median age was 48 years (range one to 93), 64% was male. In 73% the CTT was activated and in 27% the STT, although the STT was upgraded three times. Seventy-nine patients had to be admitted, with a median length of stay of five days (range one to 62). 38 patients needed ICU admission with a median ICU stay of three days (range one to 33). In total, nine patients died of which three patients died in the resuscitation room, . With this TTA system, over triage was 29% and under triage 7%. No significant differences were found for mortality, duration of hospital admission or ICU admission across the four groups (correct activation of STT, under triage, over triage, correct activation of CTT).

CONCLUSIONS

This TTA system identifies those patients in need of a CTT adequately with an under triage percentage of 7%, indicative of improved care for the severely injured and a more appropriate use of resources. With this model over triage is set to an acceptable percentage of 29%.

INTRODUCTION

In The Netherlands hospitals are divided into three levels of trauma care according to their expertise and facilities for the assessment and treatment of severely injured patients. A Level I trauma center provides the highest level of care to severely injured patient, it has a full range of specialists and equipment available 24 hours a day1. With the designation of eleven level-I trauma centers in The Netherlands, the prehospital triage system has evolved as patients are transported to the appropriate trauma center more quickly1. Consequently, in hospital triage systems have become more important in order to enhance trauma care and to minimize triage errors. In hospital triage is now considered an important function of the Emergency Department (ED). In hospital triage involves amongst others the decision which trauma team should be activated based on a prehospital report of (helicopter) emergency medical services ((H)EMS), providing rapid and adequate care for patients with time-critical and life-threatening injuries whilst using all valuable resources properly. Over triage can be described as unnecessary mobilization and utilization of medical resources for patients without significant injury, whilst under triage is defined as inadequate treatment of patients that are significantly injured2. Frequent over triage, leading to unnecessary mobilization of full resources, can demotivate staff due to redundancy of their efforts and can negatively impact the trauma team's responsiveness3. In this Level 1 trauma center, an alteration was made in the in hospital triage system. The former system was a single tiered system, always activating the entire general trauma team (GTT). Consequently, this GTT was often activated for stable patients with minor injuries, which can be considered overtriage4. A previous study showed that up to 33% of the patients presented to the trauma resuscitation room were discharged without the need of care of the GTT or even without being admitted. This can also be considered as the patient receiving a higher level of care than needed4. A considerable percentage of over triage is deemed necessary to minimize under triage, a percentage of 50% is accepted by the American College of Surgeons Committee on Trauma5. However the former system generated an over triage percentage above this limit4. A study by Boyle et al. showed that mechanism of injury criteria are poor predictors of patients who will go on to be hospital defined major trauma patients. Individual mechanisms of injury have no clinical significance in pre-hospital trauma triage in the absence of physiological instability and/or significant pattern of injury6. To improve in hospital triage the trauma team activation (TTA) system was changed in January 2013 from a single tiered TTA system based on high energy trauma, to a two-tiered TTA system based on specific criteria concerning patient vitals, mechanism of injury and type of injuries sustained. In this new system, either of a complete trauma team (CTT) or a selective trauma team (STT) can be dispatched. Table 1 shows the constitution of both teams and Table 2 shows the criteria for activation of the CTT.

Table 1. Constitution of the trauma teams

Selective trauma team (STT)	Complete trauma team (CTT)
Emergency physician	Emergency physician
Resident of the Emergency department	Trauma surgeon
Emergency department nurse	Two emergency department nurses
Diagnostic radiographer	Anesthesiologist
Resident of the Radiology department	ICU staff/fellow
	Radiologist
	Two diagnostic radiographers
	Neurologist

ICU: intensive care unit

Table 2. Criteria for activation of the complete trauma team

- Airway obstruction
- Insufficient breathing/ (tension) pneumothorax/ flail chest/ inhalation injury
- HR > 120/min
- RR < 100mmHg systolic
- Saturation < 95% O2 (despite oxygen therapy)
- Capillary Refill > 4 sec
- GCS ≤ 13/ pupillary deviations
- Estimate blood loss > 500ml
- Penetrating trauma of the head/neck/thorax/pelvis/groin area
- Long bones (femur/ tibia/ humerus) factures ≥ 2
- Rib fractures > 4
- Spine injury/ paraplegia
- BSA > 20% or in the head/neck area
- Presents or involvement of P-EMS
- Age > 70 years

HR: heart rate, RR: "Riva-Rocci" abbreviation for blood pressure, GCS: Glasgow Coma Scale, BSA: burn surface area, P-EMS: Physician staffed Emergency Medical Service

When an announcement does not meet the criteria for the CTT, the STT is activated. The rationale behind this division was to allocated resources more properly7-9. This is done to minimize over triage and facilitate appropriate use of staff and resources, since over triage may be costly and inefficient10. The CTT aims to rapidly resuscitate and stabilize the most severely injured patient and to reduce the time to diagnosis and treatment. A team approach allows for the distribution of the several tasks in assessment and resuscitation of the patient among a number of specialists9,11. This can lead to a reduction in time from injury to definite intervention12. The STT provides care for patients without abnormalities in their vital functions or without significant injuries, who require a lower level of care. This study aimed to evaluate the effectiveness and safety of the implementation of a two-tiered system and whether the triage is done according to the TTA criteria.

METHODS

This concerns a prospective observational cohort study, which was approved by the local Medical Ethical Review Committee. The cohort comprises all consecutive trauma patients who presented to the trauma resuscitation room of our Level 1 trauma center by Emergency Medical Services (EMS) or Helicopter-EMS (HEMS) within a period of three months. To be eligible for inclusion, patients had to be announced by (H)EMS and had to be presented to the trauma resuscitation room with the pending alert for either a STT or CTT. Patients were excluded when presented without any notification or if there was no or incomplete registration of the announcement on the TTA form, if dead on arrival, if in hospital data was incomplete or if a patient was relocated to a different hospital. Data on patient characteristics, TTA criteria and in hospital data where obtained. Data collection was done by collection of the trauma resuscitation room registration forms, this entails the patient number, TTA criteria, which trauma team was activated, upgrading or downscaling. In hospital data were collected by linking patient numbers to data that is registered in the in hospital and to the regional trauma database (RTDB). Variables that were retrieved were: patient demographics and characteristics, outcomes of performed Focused Assessment with Sonography in trauma (FAST) exams, additional radiological examinations, arterial blood gas (ABG) analysis, length of stay (LOS), Intensive Care Unit (ICU) admission, length of ICU admission, in hospital mortality and 30-day mortality.

Analysis

Major trauma patients are classified as those with an ISS > 15. Correct classification of trauma team was assed using the CTT dispatch criteria. All data were compared for the CTT versus STT. ISS version 2008 was used and was calculated from the abbreviated injury scale for each body region and represents the severity of the injuries sustained. The sums of accurate and inaccurate dispatches were presented for both trauma teams. The calculation of over- and under triage was based on the assumption that all of the patients who meet the major trauma patient criteria should have access to the care of the CTT upon hospital admission. Under triage is defined as the proportion of patients who meet the major trauma criteria but were triaged to the STT. Comparison between trauma teams was done for in hospital mortality, 30-day mortality, LOS, ICU admission, ISS score and length of ICU stay. The statistical data analysis was performed using SPSS 21.0. statistical analysis program (SPSS Inc., Chicago, IL). Groups were compared using the χ^2 test for categorical variables, or t-test and the Mann–Whitney U-test for continuous variables. Data are presented as percentages for categorical data, as means and standard deviations for normally distributed numerical data and as median and inter-quartile range for skewed numerical data. Differences were considered to be statistically significant with a p-value smaller than 0.05.

RESULTS

Between October 1st 2014 and January 1st 2015 a total of 186 patients were presented to the trauma resuscitation room. Thirty-four patients were excluded: eleven patients because of a non-traumatic event, 23 were excluded due to due to non-registration of the CTT criteria. The remaining 152 patients were included for further analysis. Of the included patients, 64% was male and the median age was 48 (range one to 93 years) (study characteristics Table 3).

Table 3. Study and patient characteristics

Total trauma resuscitation room presentations	**152**
Gender (male)	93 (63.7%)
Median age	48 (1 - 93)
Selective trauma team	36 (27.1%)
Complete trauma team	97 (72.9%)
Upgrading	3
Admissions	79 (52%)
Median days of admission	3 (1 - 94)
ICU admissions	38 (25%)
Median days ICU admissions	3 (1 - 33)
Overall mortality	9 (5.9%)
Departed in shock room	3

ICU: intensive care unit. Ranges given are interquartile ranges.

When reviewing the CTT dispatch criteria, activation of CTT was mainly based on mechanism of injury. In 22 cases there was an airway obstruction or an airway tube placed in the prehospital setting. In four cases there was insufficient breathing, there were five patients with a heart rate > 120/min, eleven patients had a systolic blood pressure < 100mmHg, ten patients had a O2 saturation < 95% despite oxygen therapy, one patient had an estimated blood loss of more than 500 ml, there were nineteen patients with an Glasgow Coma Score (GCS) ≤ 13 and two patients had pupillary abnormalities. Concerning the injuries, in four cases there was a penetrating trauma to the head, neck, torso, pelvis, groin area. Six patients had more than two long bones fractures and four patients had a suspicion of more than four rib fractures. Two patients were suspected to have an unstable pelvic fracture, in 36 cases a physician staffed EMS was involved and there was one paraplegic patient. Concerning the age, 24 patients were older than 70 years. There were no patients who presented with burns with a burn surface area (BSA) > 20%, a capillary refill of more than four seconds, spine injury, flail chest, tension pneumothorax or inhalation injury. In 19 cases, it was not registered whether the CTT or the STT had been deployed, therefore they were excluded for further analysis with regard to the division of the CTT and STT. The new two tiered model yielded an over triage percentage of 29% with an associated under triage percentage of 7% (Table 4).

Table 4. Evaluation of appropriateness of triage

Met CTT criteria	Trauma team	Group	N
Yes	CTT	Correct CTT	59 (44.4%)
No	CTT	Over triage	38 (28.6%)
No	STT	Correct STT	27 (20.3%)
Yes	STT	Under triage	9 (6.7%)

CTT: complete trauma team, STT: selective trauma team, N: number

Table 5. Additional radiological and laboratory examinations

	STT (% of total STT activations)	CTT (% of total CTT activations)
Chest x-ray	23 (67.6)	84(84.8)
X-Cervical spine	0 (0.0)	7 (7.1)
X-Thoracic spine	4 (11.8)	22 (22.2)
X-Lumbar spine	8 (23.5)	23 (23.2)
X-Pelvis	17 (50.0)	69 (69.7)
US of the abdomen	20 (58.8)	73 (73.7)
CT brain	15 (44.1)	71 (71.7)
CT Cervical spine	12 (35.3)	53 (53.5)
CT Thoracic spine	6 (17.6)	41 (41.4)
CT Lumbar spine	4 (11.8)	38 (38.4)
CT thorax	8 (23.5)	41 (41.4)
CT abdomen	6 (17.6)	37 (37.4)
CT pelvis	4 (11.8)	35 (35.4)
US	3 (8.8)	16 (16.2)
ABG	11 (32.4)	63 (63.6)

STT: selective trauma team, CTT: complete trauma team, X: x-ray, US: ultrasound, CT: computerized tomography scan, ABG: arterial blood gas analysis

No statistical significant difference was found for ISS score across the four groups (correct activation STT, under triage, over triage, correct activation CTT). Likewise, no statistical significant difference were seen across the four groups in hospital mortality, 30-day mortality, LOS, ICU admission or duration of ICU admission. When reviewing the additional examinations requested per team, an almost 1:4 ratio was seen in the total number of requests (resp. STT vs CTT). When reviewing the additional radiological examinations requested per team, an almost 1:4 ratio was seen in the total number of requests (resp. STT vs CTT). The STT had no abnormalities on chest x-ray in 52.9% (n=18) and the CTT in 56.6% (n= 56). ABG analysis was performed in an almost 1:6 ratio and FAST exams in a 1:5 ratio. All additional examinations are shown in Table 5.

DISCUSSION

The implementation of a two-tiered TTA protocol in our Level 1 trauma center led to a substantial change in response in the trauma resuscitation room, with no evidence of adverse outcomes. The STT now manages 27% of all the trauma resuscitation room presentations, this is thought to decrease cost because of better utilization of resources and furthermore improve trauma care13-17 . In the study period 186 patients were included in the study, however this number is lower than the actual number of trauma resuscitation room presentations. This is due to underreporting and under registration of TTA forms, since some triage nurses did not fill out the TTA form or the form got lost in process of a trauma resuscitation room presentation. The normal incidence of shock room presentations is around 3-4 per day, whereas the incidence in our study was approximately two per day. The missing shock room presentations could not be retrospectively included as we did not have the information on the TTA forms. However, the usage of the new model did enhance pre-to-in hospital communication, because the triage nurse was inclined to ask more questions regarding the pre-hospital situation which will help in the identification of the severely injured patient. This study evaluates the TTA based on both physiologic and anatomic criteria. Studies focusing solely on mechanism report over utilization of the teams resources and is not cost effective18-20. Studies combining physiologic and anatomic criteria shows increased usefulness in triage scheme decision making process21. Therefore the new TTA model, which triages not solely on MOI but also on vital parameters, injuries sustained and other risk factors, reduced the number of TTA in which the entire trauma team were required to attend. This study shows that the new two-tiered system appropriately identifies those patients in need of care of the CTT. Only nine (6.8%) patients should have been cared for by the CTT but received the care of the STT, although this did not influence mortality or morbidity across this group. The over triage rate in the new model is 28.6% (38 patient who did not meet CTT criteria that did receive care of the CTT) which is within the range as recommended by the American College of Surgeons Committee on Trauma5. This is comparable with the number Fung Kon Yin et al. report in a similar trauma center in a comparable geographical setting2. Overall, the data suggest that the activations system works as intended to identify severely injured patients for activation of CTT. The request for additional (radiological) examinations shows an almost 5:1 ratio when comparing the CTT with the STT. This is probably because the new criteria are superior in identifying the severely injured compared to the triage based solely on mechanism of injury. Less injured patients seen by the STT consequently needed less radiological exams. This substantiates the thought that the new activation system will better utilize resources and reduces costs. This study is subject to a number of limitations. The prehospital measurement and interpretations of vital signs, injuries and the mechanism of trauma is subject to intra observer variability. Another limitation is selection bias of patient inclusions due to missing activation forms as the actual number of trauma resuscitation room presentation is higher. Leading to a less then optimal sample collection.

This study reports on the alteration from a single tiered TTA system based on mechanism of injury to a two-tiered TTA system based on vital signs and injuries sustained. Based on these new criteria, either a complete trauma team or a selective small trauma team is activated in the trauma resuscitation room. The usage of the new model may aid to enhance pre-to-in hospital communication. Though prehospital identification of the severely injured remains a strenuous matter, our results suggest that the two-tiered system ensures appropriate trauma care whilst optimizing the utilization of limited surgical resources.

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Chapter 9

Ten year maturation period in a Level I Trauma Center, a cohort comparison study

ABSTRACT

Purpose

Many changes have been made to improve trauma care. Improved trauma team system and usage of a hybrid resuscitation room are examples of how this trauma center has developed. The aim was to assess how outcome of the trauma population was influenced by the maturation.

Methods

A cohort comparison, between June 2004 - July 2005 and 2014 was performed. All adult trauma patients with an Injury Severity Score (ISS) > fifteen were included. Variables collected were: patient demographics, mechanism of trauma, total prehospital time, pre- and in hospital trauma scores, vital signs, blood values and interventions, Helicopter Emergency Medical Services (HEMS) involvement and outcome.

Results

From June 2004 to July 2005 219 patients were admitted, for the year 2014 this was 282 patients. The 2014 cohort was significantly older (mean age of 53.6 ± 23.8 vs 45.6 ± 22.7 years). The mean RTS did not differ. HEMS assists increased to 116(13.5 %). The number of CT-scans, blood transfusion and acute trauma surgical interventions decreased. Mean LOS, ICU admission and ICU LOS did not differ. The mortality rate however decreased by 7.0%, observed and predicted survival was significantly different in favor of the 2014 cohort, with a Z-score of 4.25.

Conclusion

An increase in age is seen, though trauma scores remain comparable. The number of blood products transfused and acute trauma surgical interventions performed declines. Mortality significantly decreased and a significant difference in observed and predicted survival is seen. Showing improved trauma care in our hospital, in favor of the second period.

INTRODUCTION

The number of deaths due to injury has increased over the last decades. Nowadays, over 15.000 people die each day as a result of injury. It accounts for nine per cent of the world's deaths annually [1]. Most of these deaths are traffic or violence related, which are predictable and largely preventable causes of injury. Consequently, many efforts have been made to reduce these numbers by improving quality of trauma care and subsequently improving trauma patient outcome. Prehospital trauma care has evolved significantly, amongst others due to: implementation of trauma centers, more protocolled work in dispatch centers and on the ambulances, implementation of a mass transfusion protocol and by extending prehospital trauma care with the Physician staffed Helicopter Emergency Medical Services (P-HEMS). The P-HEMS supplements the prehospital trauma life support performed by the EMS with advanced trauma care. A Dutch P-HEMS can perform procedures such as rapid sequence intubation, administer advanced pain medication, inotropes, vasopressors and other medication. Moreover, a P-HEMS can perform invasive surgical interventions [2]. These prehospital intervention strategies are amongst others of influence on the patient's hemodynamic parameters and survival. One can imagine that this affects the characteristics of the trauma patient population that does not die in the prehospital setting and is brought to a trauma center. Furthermore the in hospital triage systems have changed as well. This level 1 trauma center now uses a two-tiered trauma team activation model. Trauma team activation is based on specific criteria concerning patients vitals, mechanism of injury and type of injuries sustained. Either a complete trauma team or a selective trauma team will subsequently be dispatched. Other in hospital changes are the availability of a hybrid emergency resuscitation room [3] and implementation of a massive transfusion protocol [4, 5]. The objective of all these efforts is to reduce morbidity and mortality for those who do suffer an injury and to allocate resources properly. This in order to reduce over and under triage. Earlier studies evaluating maturation of Level one trauma centers show an improve in outcome [6-8]. It is of great importance to evaluate the transformations made to improve trauma care. Therefore, the aim of this observational cohort comparison study was to assess, how the outcome of the trauma population treated in this Level 1 trauma center was influenced by the maturation of the pre- and in hospital trauma care as we hypothesize an improvement in survival could be seen. Furthermore, we were interested to see changes in trauma mechanisms, occurrence of injuries and treatment at our trauma center.

METHODS

Data collection

We performed an observational cohort comparison study. Data was collected for all adult trauma patients with an Injury Severity Score (ISS) above fifteen, who were admitted to a level 1 trauma center, in 2014. This cohort was compared to a historical cohort likewise comprising trauma patients admitted with an ISS > 15 between June 2004 and July 2005. For the purpose of this study data was collected from two databases. (1) Data for both cohorts were obtained from the National Regional Trauma Database (NRTD) located at the trauma center. The NRTD is the national trauma registry, implemented by the Dutch ministry of health and governed by the National Network Acute Care (NNAC). The data collection and coding is locally done by dedicated database managers and data verification and validation is done by the NNAC. It is a registration system for all trauma patients in the Netherlands and we retrieved only the data for the patients admitted to this level 1 trauma center. (2) Furthermore, data were retrieved from the in hospital patient registration system. The NRTD was searched by using a query in the ISS field box-selecting patients with an ISS above 15 to include only the severely injured, to calculate ISS the updated version 1998 of AIS was used [9]. Patients were matched to the In hospital patient registration system using a personal code. Variables that were retrieved were: patient demographics, details on trauma mechanism, duration of prehospital time intervals, prehospital trauma scores, prehospital vital signs, Physician staffed Helicopter Emergency Medical Services (P-HEMS), emergency room (ER) vital signs, ER trauma scores, ER arterial blood gas values, intoxication status, emergency intervention, transfusion of blood products, length of stay (LOS), number of days of Intensive Care Unit (ICU) admission and in hospital mortality. Patients were excluded if dead on arrival, incomplete prehospital or in hospital data or patients who were relocated to a different hospital.

Analysis

The statistical data analysis was performed using SPSS 21.0. Statistical Analysis program (SPSS Inc., Chicago, IL). Continuous data is reported as mean with standard deviations (SD) for normally distributed data or as median (5-95 percentiles with Inter Quartile Rage (IQR)) for not normally distributed data. The ISS is calculated from the abbreviated injury scale for each body region and represents the severity of the injuries sustained. The probability of Survival (Ps) was determined using the Trauma Score Injury Severity Score (TRISS) formulae [10], using variables from both databases for both cohorts. The TRISS determines the Ps based on a patient's ISS, revised trauma score (RTS), age and type of trauma (blunt or penetrating trauma). Differences between the two groups with respect to mechanism of injury were assessed using the Chi-square tests with Bonferroni correction, significance of statistical differences was attributed to a two tailed P value < 0.05. Student's t-test and Chi-square tests were used to test for differences in duration of hospital stay, ICU stay and mortality for the two cohorts, statistical significance was set at $\alpha = 0.05$. Logistic regression analysis was used to compare survival in both cohorts, adjusted for age and ISS score. The Z-statistic was calculated to evaluate the difference between predicted and observed survival. A negative Z-statistic indicates the observed survival to be lower than the predicted survival and a positive Z-statistic indicates the observed survival to be higher than the predicted survival, p-values <0.05 were considered statistically significant [11, 12].

RESULTS

From June 2004 to July 2005 219 patients were admitted with an ISS >15. For the year 2014 this was 282 patients with an ISS >15. Patient characteristics for both cohorts can be found in table 1. The 2014 cohort was significantly older than the 04-05 cohort with a mean age of 53.6 ± 23.8 years (median of 55,0 years) versus a mean age of 45.6 ± 22.7 years (median of 43,6 years)($p < 0.001$). The male/female ratio and the mean ISS score did not change from one study period to the next. The mean RTS and Glasgow Coma Scale (GCS) likewise did not differ for both cohorts. Compared to the first period, the number of HEMS assists increased by 13.5 % ($p < 0.001$). The total prehospital time did not differ. RTS and GCS on arrival at the emergency room remained unchanged as did pH and hemoglobin levels. Additional biochemical parameters can be seen in table 1. When reviewing the mechanism of injury the proportion of motor vehicle crashes significantly declined from 38 (17%) in 04-05 to 20 (7%) in 2014 using the Chi-square tests with Bonferroni correction. The category "other" mechanisms increased significantly from zero cases in 04-05 to 21 cases in 2014. The proportion of further mechanisms of trauma did not differ significantly from one study period to the next. When grouped together, the number of penetrating injuries differed significantly, since there were three (1.5%) penetrating injuries in 04-05 compared to 14 (5.0%) in 2014.

Table 1. Patient characteristics

	2004-2005	2014	p value
Patients, n	219	282	n.a.
Male, n (%)	145 (66.2)	195 (69.1)	0.485
Mean age ± SD	45.6 ± 22.7	53.6 ± 23.8	<0.001
ISS	24.0 ± 8.1	23.2 ± 7.8	0.267
Prehospital RTS	6.4 ± 2.0	6.8 ±2.3	0.190
ER RTS	6.5 ± 1.8	6.5 ± 2.0	0.844
Prehospital GCS median (IQR)	14 (6-15)	14 (7-15)	0.935
ER GCS median (IQR)	14(4-15)	14 (3-15)	0.961
P-HEMS presence, n (%)	61 (27.9)	116 (41.4)	0.001
OST			
TPT	44.7 (15.2)	45.4 (12.6)	0.063
Intubation	n.r	38 (13.5)	
ER pH	7.33 (0.1)	7.4 (0.1)	0.055
ER BD	-2.7 (2.9)	-0.7 (3.7)	<0.001
ER pO2	202.0 (110.5)	126.7 (99.8)	<0.001
ER Hb	7.7 (1.5)	7.5 (1.6)	0.272

n = number, n.a.= not applicable, ISS= Injury Severity Score, RTS= revised trauma score, ER= emergency room, IQR = inter quartile range, CGS = Glasgow coma score, P-HEMS= physician staffed helicopter emergency medical service, OST = on scene time, TPT = total prehospital time, n.r= not recorded, pH= numeric scale for acidity, BD = base deficit in mmol/L, pO2 = partial pressure of Oxygen in mm Hg, Hb = hemoglobin levels in mmol/L.

Table 2. Mechanisms of injury

	2004-2005	2014
Fall of height > 2 meters	71	69
Same level fall	13	39
Pedestrian injured	21	13
Cycling crash	32	45
Scooter/motor vehicle crash	26	39
Car vehicle crash	38*	20*
Crash involving large vehicle	1	0
Drowning/suffocation	0	6
Burns	0	3
Violence	7	6
Crush injury	7	8
Penetrating injury n (%)	3	14º
Gunshot injury	1	5
Stab injury	2	9
Other	0*	21*

ºsignificantly different between two time cohorts using the Chi-square test * sig different using the Chi-square test with Bonferroni correction

An overview of the mechanisms of injury is presented in table2. An overview of all in hospital interventions is presented in table 3.A significant decrease is seen in the number of intubations and CT scans in the 2014 compared to 04-05 ($p = 0.008$ and $p=0.044$). The number of packed cells (PC) and fresh frozen plasma (FFP) transfused within 24 hours of arrival likewise decreased significantly, for PC this was 1.0 for 2014 vs. 2.7 for 04-05 ($p = 0.011$), for FFP this was 0.4 for 2014 vs. 1.0 for 04-05 ($p = 0.001$). When looking at the total amount of blood products transfused within the entire period of admission. The number of packed cells (PC) and fresh frozen plasma (FFP) decreased significantly, the number of total acute interventions lessened by 14.3% ($p = 0.001$), the number of acute trauma surgical interventions reduced by 8.8% ($p = 0.005$). However, the number of acute angio interventional radiology procedures increased significantly from 2 in the 04-05 cohort to 10 in the 2014 cohort ($p = 0.002$). Focusing on the different outcome measures, mean LOS was 14 ± 16 days for the 2014 cohort, which is not significantly different to the 20 ± 29 days for the 04-05 cohort. ICU admission and length of ICU admission did not differ from one study period to the other. The cumulative mortality proportion however decreased by 7.0% ($p = 0.043$). The mean probability of survival did not differ for both periods. After adjusting for ISS and age using logistic regression analysis, the 2014 cohort had an OR of 1.9 for survival (95% CI 1. 14- 3.3; $p = 0.014$) compared to the 04-05 cohort. The mean probability of survival was not significantly different, whereas the difference in observed and predicted survival was significantly different in favor of the second period. The Z-score of the 2014 period, $Z = 4.25$ ($p = 0.002$) showed a significant positive difference between the observed and predicted survival. Further outcome measures are depicted in table 4.

Table 3. Interventions

	2004-2005	2014	p value
Intubation, n (%)	38 (17.4)	26 (9.3)	0.008
CT-scan, n (%)	201 (93.1)	247 (87.6)	0.044
PC 24h	4(2-9)	2 (2-5)	0.011
FFP 24h	4(3-7)	3.5 (2-6)	0.001
Pl 24h	1(1-2)	1(1-2)	0.128
PC total	6 (2-10)	3(2-6)	<0.001
FFP total	4 (3-7)	3(2-6)	<0.001
Pl total	1(1-2)	2(1-2)	0.109
Acute intervention	85 ± 38.8	75 ± 26.6	0.001
Trauma, n (%)	41 (18.7)	28 (9.9)	0.005
Neuro surgery, n (%)	44 (20.1)	61 (21.6)	0.674
Maxillofacial, n (%)	4 (1.8)	1 (0.4)	0.100
Angio intervention, n (%)	2 (1.0)	10 (3.5)	0.002

n = number, CT-scan= computed tomography scan, PC= packed cells, FFP= fresh frozen plasma, Pl: platelets

Table 4. Outcome measures

	2004-2005	2014	p value
Median LOS (IQR)	11 (4-25)	9 (4-18)	0.162
ICU admission, n (%)	135 (61.6)	183 (64.9)	0.454
Median ICU LOS (IQR)	2 (0-5)	2 (0-5)	0.376
In hospital mortality, n (%)	47 (21.5)	41 (14.5)	0.043
TRISS			
Mean Ps	0.79	0.78	0.952
Expected Mortality	16.3 %	16.0%	
Observed mortality	0.27	0.19	
Z-score	-0.48 (p = 0.31)	4.25 (p < 0.0002)	

LOS: Length of stay, IQR= inter quartile range, n = number, ICU = Intensive care, SD: Standard deviation, ICU: Intensive Care Unit, TRISS= Trauma and Injury Severity Score

DISCUSSION

This study compares two cohorts of severely injured patients admitted to an urban level one trauma center almost ten years apart. The data presented shows that impressive changes have occurred over this period. The goal of a trauma center is to enhance and optimize care of the severely injured patient [13]. In order to do so, several changes in trauma care have been made, amongst others renewing of the emergency resuscitation room [3], implementation of an improved two tiered triage system, and implementation of a massive transfusion protocol [4, 5]. The aim of this observational cohort study was to evaluate the outcome of the major trauma patient in a level 1 trauma center after all these alterations. We compared two cohorts, the first covering the period from June 2004 to July 2005 and the second covering the entire year of 2014. This was done because form January 2015 on the ISS scores are calculated differently and therefore no longer comparable to the historical cohort [14]. Besides the increase in the total number of admitted patients with an ISS >15, the eight year increase in the mean age of the second cohort is remarkable. This could be due to aging of the entire population. Since trauma is a disease process that affects all age groups, elderly make up one of the fastest growing segments. Furthermore, mortality and morbidity are influenced by age, physical condition and comorbidities and therefore elderly might be triaged to a higher level trauma center more quickly than their younger equivalents [15, 16]. The 13% increase in P-HEMS presence in the prehospital phase is most likely due to the fact that in 2009 the Dutch government granted 24/7 coverage for the four Dutch HEMS crews, allowing them to also do night flights [17, 18]. The increased prehospital presence of the P-HEMS is very likely to lead to an increased prehospital intubation rate [19]. This could in turn explain the decreased ED intubation rate. In the 2014 cohort significantly less acute interventions are performed, especially less trauma surgical intervention. This could be due to increased sensitivity of the CT-imaging, allowing the surgeon to treat clinically significant injuries more properly and thus treating patients more frequent with a non-surgical approach [20,21]Kenn W, Roewer N, Brederlau J</author></authors></contributors><titles><title>Whole-body multislice computed tomography (MSCT. The decline in acute trauma surgical interventions can also be attributed to the increased usage of angio interventions. Angio embolization has gained in popularity in identifying and arresting bleeding in trauma patients, decreasing the need for surgical intervention [22, 23]. Also, for the 2014 cohort a decrease is seen in the usage of blood products. Especially packed cells and fresh frozen plasma, both in the acute setting as for the entire duration of admission, are transfused less than in the 04-05 period. One could think that usage of the MTP is reason for this decline [24]. The decline in crude mortality rate can be attributed to many factors as outcome is greatly affected by time to definite care, quality of care, injury severity and patient factors [25, 26]. Total prehospital time and trauma scores did not differ for both periods, however the 2014 cohort was significantly older. This correlated with the extensive comorbidity [27]. Though even in the absence of co-morbidity age is a known risk factor of adverse outcomes independent of other patient characteristics [28, 29]. We can conclude that progress has been made in trauma care of this level one trauma center as we observed a significant difference in mortality rates and in observed and predicted survival in favor of the second period, with a Z-score of 4.25. Thus, indicating significantly more survivors in our institution than expected. The improvement in survival can be attributed to improvement in quality of care over time as well as the changes that this trauma center has undergone. Likewise it is proven that a surgeons experience with the trauma center or system positively influences outcome, as this attributes to the improvement over time [30]. A limitation of this study it its retrospective nature. And the usage of trauma registries, as this was main reason for missing ISS or RTS scores. Another limitation is that we were only able to analyze variables that were collected during both periods, minimizing the comparisons to be made because not all parameters were scored during the first cohort. Furthermore we only assessed in hospital outcome, one could deliberate on outcome one year after trauma to be a better reflection of outcome. Finally, because we are measuring on a process or organizational level one can not specify to what changes the positive influence in outcome can be attributed.

CONCLUSIONS

When comparing the cohort of the year 2014 to the cohort of 04-05 one can see a marked increase in mean age of the severely injured patient, though trauma scores remain comparable. The total number of acute interventions declined, mainly the number of trauma surgical interventions, whereas the number of acute angio interventions significantly increased. In light of all these changes mortality significantly declined for the most recent cohort, furthermore the observed survival was better than the predicted survival. Demonstrating improved trauma care in our hospital, in favor of the second period.

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Chapter 10

General discussion

Since the first introduction of physician staffed helicopter emergency medical services (P-HEMS) in the Netherlands, there has been debate on the additional value of the advanced therapeutic options a P-HEMS can provide. A lot of research has been done into the survival benefit and cost-efficiency of P-HEMS care. It has been proven to increase the odds for survival for the severely injured and the moderately injured patient whilst keeping the costs per Quality Adjusted Life Year below the accepted threshold. However P-HEMS care is a high-visibility and resource-consuming expense and therefore subject to public debate, forcing the field to continuously review their work. Prehospital trauma systems are therefore constantly evolving. Examples within the Dutch system are for instance the institution of regionalized trauma care, implementation of ambulance protocols or the implementation of trauma registries. However proper P-HEMS care depends on continuous training, education, skill improvement, monitoring and research. Trauma care is integrated care and according to the national guidelines one of the success factors in trauma care is the quality of the collaboration between different health care providers in the chain. One of the next steps to improve Dutch prehospital trauma care through research is to try to address the collaboration and optimize the dispatch and cancellation of both P-HEMS and EMS.

In order to do so, this thesis addresses early trauma care for the severely injured patient. We focus on both prehospital trauma care provided by emergency medical services (EMS) and P-HEMS as well as in hospital care by trauma teams. When trying to optimize the deployment of the P-HEMS, primary question that arises is how one can identify which patient is in need of care by P-HEMS? Though in trying to answer this question, more questions arises. This because prehospital trauma care is subject to so many different variables and in its current form is a relatively new fledged type of care. Before trying to identify a patient in need of care by the P-HEMS, we first need to gain more insight into the factors at play, prior to structure and protocol prehospital trauma care. This because we are not simply looking at patient factors but also situational factors, creating a unique situation for every trauma dispatch. A dispatch is not just dependent on solely measuring the vital parameters or looking at the injuries sustained. It also has to do with the assessment of a layperson on-scene, the content of the distress call to the dispatch center (DC), the interpretation of this information by the dispatch operator, the usage or non-usage of a (protocolled) dispatch program and the subsequent deployment of different types of EMS. Furthermore the prehospital logistics, the locations of the accident, the distance to the nearest trauma center, the availability of EMS and P-HEMS and the weather are of influence. Moreover the assessment of the EMS nurse at the scene plays an important role, as does the exposure of the EMS nurse to severely injured patients or the communication between DC and EMS and P-HEMS and consequently the information handed over to the P-HEMS. Furthermore the interpretation of the hectic of the situation, the time spent in the prehospital setting and the skills of the EMS nurse to secure the ABCD are of influence. When reading this enumeration one can understand that it is difficult to provide a structured answer to the first research question which is applicable to every prehospital trauma patient. In order to elucidate some of the factors at play, we focused on assessing what factors are major contributors in the decisions making process, how can we influence these and what are shortcomings in current practice.

A factor that is perceived to be of great influence on the outcome of a trauma patient is the time spent in the prehospital setting. It is difficult to solely address the factor time on trauma patient outcome. This is reflected in the heterogeneity of the included studies included in Chapter 2. In this chapter we review the duration of several prehospital intervals on trauma patient outcome. However, various types of patients groups, mechanisms of trauma, types of prehospital trauma care or trauma scores are clustered and analyzed, disregarding there independent effect on mortality. Through carefully reviewing the data we conclude that for undifferentiated trauma patients shorter response time and transport time may have a positive influence on mortality. However longer on-scene-times of EMS and P-HEMS may increase odds of survival. The same goes for increased total prehospital time, probably due to the relatively large proportion of on-scene time in total prehospital time. This leads us to believe that not merely time but prehospital interventions performed and the type/level of care are a major contributors on trauma patient outcome. P-HEMS provide a more extensive type of care in the prehospital setting, though this may lengthen prehospital time intervals. Lessons that one may learn is not to stress to much with regard to the factor time, but focus more on the deployment of the appropriate type of care. Though, swiftness of transport does seem beneficial for patients suffering traumatic brain injury or hypotensive patients suffering penetrating trauma.

To improve prehospital trauma care and dispatch the P-HEMS more adequate is seems important to identify patient in need of care by an P-HEMS team early in the process. To investigate this and review other factors of influence on prehospital trauma care the DENIM (a Delphi-procedure on the identification of prehospital trauma patients in need of care by Mobile Medical Teams (P-HEMS)) was performed. This study reveals communication to be of utmost importance (Chapters 6 and 7). To further address this topic we looked into the current status of prehospital communication and handovers between all EMS and the dispatch center in Chapter 3. Tape-recordings of communication between the ambulance, DC and the helicopter for trauma related dispatches were transcribed and analyzed. It showed that in only 17% of all dispatches a complete situational report was handed over, either using the ABCD-methodology (5%), the Situation-Background-Assessment-Recommendation technique (9%) or the Mechanism-Injuries-Signs -Treatment method (2%). All other handovers were incomplete. EMS on scene are responsible for a direct and clear situational report. Based on this information, the P-HEMS physician is responsible to ensure him- or herself if continuation of P-HEMS dispatch is necessary or if the mission can safely be aborted. Therefore the handover is essential for the quality and continuity of care. A structured communication format can add to this, currently several different acronyms exits to aid EMS in their handover. Though this study shows limited usage of the current models. Furthermore the DENIM (Chapter 6 and 7) shows a national consensus on that, simply reporting "ABCD-stable" is insufficient to make an educated decision and likewise there is consensus among all professions in the field of prehospital trauma care on the need for a new and structured model for handover. This will aid to standardize prehospital handovers, so more patient and situational information is provided, to increase joined decision-making and increase quality of care and improve patient's outcome. Another conclusion from chapter 4 is that the implementation of the new P-HEMS model already enhances the flow of information. Going through the cancellation model enforces the EMS nurse to provide the P-HEMS physician with more detailed information. In Chapter 4 we review the implementation of this cancel model. To prevent high levels under triage, the Dutch trauma system handles a low activation threshold for the primary P-HEMS dispatch. Therefore it is important that attempts to reduce over- and under triage focus on the second point in triage, when EMS nurses on-scene make a first professional assessment of the situation. Based on this information a decision needs to be made to either continue or cancel the P-HEMS dispatch. In P-HEMS care, over triage causes increased costs, additional safety risks to the flight crew and shortage of P-HEMS care for higher acuity emergencies. The American Colleges of surgeons have deemed 5-10% under triage acceptable with maximum 50% over triage. Due to previously reported high cancelation rates of the P-HEMS of the Lifeliner One and low predictability for major trauma a new cancellation model for P-HEMS was designed. We identified prehospital parameters that were significant in the identification of majors trauma patients in order to design a safe triage model for cancelling unnecessary P-HEMS dispatches. Chapter 4 shows that implementation of the new cancel model yielded a high level a off accuracy for identifying a major trauma patient. The sensitivity of the new model is 0.898 (CI:0.817 to 0.945), the specificity 0.72 (CI:0.625-0.799). The positive predictive value is 0.738 (CI:0.648 to 0.812) and the negative predictive value 0.889 (CI:0.802 to 0.9840). Generating a under triage percentage of 10.2% and an over triage percentage 28%. Two cohorts before and after implementation of the cancellation model were compared. Results show that the mean age was significantly older for the recent cohort than for the former cohort. Furthermore the ISS significantly increased, this could implicate better prehospital triage for the severely injured to receive P-HEMS care. The number of acute interventions significantly increased, whereas number of patients admitted to an ICU decreased. Moreover mortality rates were comparable. The new model makes sure the most severely injured patients receive lifesaving care whilst reducing unjustified P-HEMS dispatches. This study furthermore provides us with insight into the prehospital triage of patient to different trauma centers. Fifty-three percent of all patients was transported to a level 1 trauma center, when looking at the major trauma patients this was 74%. The remaining 26% were mostly transported to level 2 but also level 3 trauma centers.

Chapter 5 provides us with a detailed protocol of the DENIM. In search for the answer to our primary research question; which acute trauma patient is in need of care by a P-HEMS a three round national digital Delphi study was initiated. Both steering committee as well as the respondent all had their occupational background within the field of pre- or in hospital trauma care such as P-HEMS physicians and nurses, trauma surgeons, EMS paramedics, emergency medical operators in the DC. Chapter 6 reveals the first results from the DENIM study. A large group of respondent completed all three rounds. For the first DENIM round, the main question asked was; which trauma patient would benefit by the advanced care

of P-HEMS? The first round was used to generate discussion and yield argumentation on the topic. The answers were used to identify topics of interest leading to statements that were presented in the subsequent round. From the first round we could conclude that it was difficult to identify what patient would benefit by the care of a P-HEMS. It appears that the identification of the major trauma patient is problematic. Moreover prehospital communication on parameters, such as vital signs, for major trauma patients is often sparse and inadequate. Therefore the second and third DENIM rounds further looked into the prehospital communication, mode and content of the prehospital communication. This because it was thought that when prehospital communication becomes more clear the P-HEMS dispatch can be evaluated more adequately, which in turn would allow use for better assessment and/or adjustment in dispatch criteria that may improves prehospital trauma care.
For the second round topics were evaluating factors influencing prehospital communication, critical information for proper handover, factors influencing collaboration and how these can be influenced from a training/educational perspective. From answers on the second questionnaire we converged to the third round, which was aimed at exactly establishing the content of a prehospital handover. Chapter 7 provides us with an extensive overview of the DENIM communication tool for prehospital trauma handover. The purpose of this study was improving prehospital communication generating consensus on the exact content of a minimal adequate prehospital handover for a trauma patient. The tool comprises of a set of ten parameters and may help to aid EMS and P-HEMS to structure the handover and provide each other with the essential information to create appropriate situational awareness.

The final part of this thesis focuses on the in hospital trauma care for the severely injured. Chapter 8 reviews the implementation of a recently introduced two-tiered trauma team activation system. To improve in hospital triage the trauma team activation system was changed from a single tiered system mainly based on high energy trauma, to a two-tiered system. This system is based on specific criteria concerning patients vitals, mechanism of injury and type of injuries the patient sustained. A divide is made in the dispatch of a complete trauma team (CTT) or a selective trauma team (STT). The CTT comprise of a more extensive team then the STT. The division was made done to minimize over triage and to allocate resources more properly whilst making sure that the severely injured patients are identified and receive the appropriate care. It appeared that the new system identifies those patients in need of care by the CTT adequately with an under triage percentage of 7%, and over triage 29%. The patients were grouped into correct CTT, over triage, correct STT and under triage. We compared all groups for in hospital mortality, 30-day mortality, length of stay, Intensive care admission (ICU) and the duration of ICU admission and found no differences across the groups. When reviewing the additional examinations requested per team, an almost 1:4 ratio was seen in the total number of requests (resp. STT vs CTT), this was the same for the additional radiological requests. Implicating higher costs for the CTT. Furthermore the implementation of the new model has led to improvement of pre-to in hospital communication. The implementation of the new trauma team response system in just one of the many changes this level one trauma center has gone through. In Chapter 9 we aim to assess how the outcome of the trauma patient population was influenced over time by the maturation of trauma care in our level I Trauma center, VU University medical center. A cohort comparison study between June 2004 - July 2005 and the year 2014 shows that even though patients increase in mean age, the mortality rate decreased by 7.0% and with a Z-score of 4.25 the observed survival was significantly higher than the predicted survival in favor of the 2014 cohort. This is implicating improved trauma care in our hospital.

In conclusion for proper dispatch and cancellation of P-HEMS early identification of the major trauma patient, a patient in need of care by P-HEMS is important. Identification of this patient however seems difficult due to no prehospital trauma patient and situation being identical and many variables are at play. It is furthermore challenging because prehospital communication and reporting on parameters is very spares. Recently, many improvements have been made in the documentation of prehospital parameters in ambulance reports and national databases, though this documentation is often done in hindsight and not in the acute moment when several EMS are trying to figure out the most appropriate dispatch of what resources. Focus on optimizing prehospital communication and information flow will therefore provide us with a better understanding of the prehospital setting. This thesis provides a evidence based tool to improve the communication between all EMS for trauma patients. Providing a structured format with a set of ten parameters which each prehospital trauma handover should entail. This thesis furthermore provides a validation of a new cancellation model which aids in safely cancelling P-HEMS dispatches. Identifying the most severely injured whilst reducing unjustified P-HEMS dispatches and maintaining low mortality rates.

Chapter 11

Nederlandse samenvatting

Sinds de introductie van het eerste Mobiel Medisch Team (MMT) is er veel discussie geweest over de toegevoegde waarde van een MMT en de geavanceerde therapeutisch handelingen die het team in de prehospitale setting kunnen uitvoeren. Er is veel onderzoek gedaan naar het overlevingsvoordeel en de kosteneffectiviteit die de MMT's leveren. Het is bewezen dat de aanwezigheid van een MMT de overleving van een ernstig gewonde of de matig gewonde patiënt doet verbeteren. Dit terwijl de kosten per Quality Adjusted Life Year voor dit type zorg binnen de geaccepteerde grenzen vallen. MMT zorg is echter een zeer opvallend en middelen verbruikend type zorg en daarom vaak onderwerp van het publieke debat. Dit zorg ervoor dat het vakgebied continu goed kijkt naar haar eigen functioneren en dat de prehospitale trauma systemen voortdurend in ontwikkeling zijn. Voorbeelden binnen het Nederlandse systeem zijn bijvoorbeeld de implementatie van geregionaliseerde traumazorg, het invoeren van ambulance protocollen of de invoering van de landelijke trauma registratie. Goede MMT zorg is afhankelijk van ontwikkeling door middel van opleiding, onderwijs, vaardigheidstrainingen, monitoring en onderzoek. Traumazorg is ketenzorg, en volgens de nationale richtlijnen is één van de succesfactoren in de traumazorg de kwaliteit van de samenwerking tussen verschillende zorgaanbieders in de zorgketen. Eén van de volgende stappen in het proces van het verbeteren van de Nederlandse prehospitale trauma zorg is dan ook het optimaliseren van de samenwerking en de inzet en cancel van de MMT's en de ambulances.

Dit proefschrift richt zich daarom op de vroege fase in trauma zorg voor de ernstig gewonde patiënt. Er wordt gekeken naar prehospitale zorg geleverd door ambulance diensten en de MMT's, als mede naar de primaire opvang van een ernstig gewonde patiënt op een shockroom in een traumacentrum door middel van verschillende trauma teams. Bij het optimaliseren van de inzet van een MMT komt er een primaire onderzoeksvraag naar voren: hoe kunnen we het slachtoffer identificeren dat baat heeft bij de zorg van een MMT? In de zoektocht naar het antwoord op deze vraag kwamen echter nog meer vragen naar boven. Dit omdat prehospitale traumazorg onderhevig is aan heel veel verschillende factoren en omdat het in haar huidige vorm een relatief nieuwe vorm van zorg is. In het proces om het slachtoffer welke baat kan hebben bij de zorg van een MMT te identificeren moeten we eerst meer inzicht krijgen in al die factoren die van invloed zijn voordat zodat we de prehospitale trauma zorg meer transparant maken, alvorens het meer te kunnen structureren en protocolleren. Men heeft namelijk niet alleen te maken hebben met patiënt factoren maar ook met grote situationele verschillen per casus, dit maakt iedere inzet uniek. De inzet van een MMT is niet alleen afhankelijk van het meten van, of afwijkingen in, de vitale parameters van een patiënt óf welke verwondingen een patiënt heeft.. Het heeft ook te maken met de inschatting van de ernst van de situatie door de omstanders ter plaatse, de informatie die de omstanders overdragen aan de meldkamer, de achtergrond van een meldkamercentralist en de interpretatie van de meldkamercentralist van deze informatie, het gebruik van een (geprotocolleerd) triage systeem op de meldkamer en de opeenvolgende inzet van verschillende typen hulpdiensten. Daarnaast speelt de prehospitale logistiek, de locatie van het ongeval, de afstand tot het dichtstbijzijnde traumacentrum, de beschikbaarheid van ambulance diensten en/of een MMT en zelfs het weer een rol. Ook is de beoordeling van de ambulance verpleegkundige ter plaatste, de blootstelling van de ambulance verpleegkundige aan ernstig gewonde patiënten, de communicatie tussen de meldkamer en de ambulance en een MMT en de informatie die naar het MMT wordt overgedragen belangrijk. Verder is de interpretatie in de hectiek en de ernst van een situatie, de tijd die wordt gespendeerd in het veld en bijvoorbeeld de bekwaamheid van een het team om de ABCD van een patiënt veilig te stellen van belang. Wanneer men deze opsomming leest kan men zich wellicht voorstellen dat het lastig is één enkel gestructureerd antwoord te geven op de primaire onderzoeksvraag welke van toepassing moet zijn op iedere trauma patiënt. Om meer inzicht te krijgen in een aantal van de factoren hebben wij ons gericht op factoren die van invloed zijn op de besluitvorming en samenwerking in de prehospitale en inhospitale situatie, hoe deze beïnvloed worden en wat hierin de tekortkomingen zijn in de dagelijks praktijk.

De tijd gespendeerd in de prehospitale setting is een factor van invloed waar van oorsprong veel waarde aan wordt gehecht. Het is echter moeilijk om uitsluitend de factor tijd op de uitkomst mate van een trauma patiënt te beoordelen. Dit ziet men mede terug in de heterogeniteit van de geïncludeerde studies in Hoofdstuk 2. In dit hoofdstuk beoordelen we de invloed van de duur van verschillende prehospitale tijds intervallen op de uitkomstmaten van een trauma patiënt. Diverse verschillende typen patiënten groepen, mechanismes van trauma, typen prehospitale zorg of traumascores worden geclusterd en geanalyseerd. Hierbij voorbijgaande aan de solitaire invloed van deze elementen op de mortaliteit. Door alle artikelen systematisch en grondig door te nemen en te vergelijken kunnen we concluderen dat voor de algemene trauma patiënt een kortere respons tijd en transport tijd van hulpdiensten naar het ongeval toe een positief effect hebben op de mortaliteit. Er blijkt verder dat langere on-scene tijden van de ambulance en/of een MMT ter plaatse een positief effect hebben op de overleving. Hetzelfde geld voor de totale prehospitale tijd, dit is waarschijnlijk door het relatief grote aandeel van on-scene tijd in de totale prehospitale tijd. Dit lijdt tot de gedachte dat niet simpel alleen de gespendeerde tijd maar voornamelijk het type geleverde zorg en de uitgevoerde interventies van invloed zijn op de uitkomst maten van een ernstig gewonde patiënt. Een MMT levert een geavanceerd type zorg in de prehospitale setting, terwijl dit vaak wel kan lijden tot een verlenging van de duur die de patiënt buiten het ziekenhuis spendeert. De les die we hier dus wellicht uit kunnen meenemen is dat we ons niet alleen zorgen hoeven te maken om de patiënt spoedig naar een ziekenhuis te vervoeren. Maar dat we moeten zorgen dat het juiste type zorg prehospitaal adequaat en op tijd wordt ingezet. Echter blijkt wel dat de patiënt met traumatisch hersenletsel of patiënten met penetrerend letsel welke hypotensief zijn baat kunnen hebben bij snel transport naar een ziekenhuis.

Om de kwaliteit van prehospitale traumazorg te verbeteren en het MMT beter te kunnen inzetten lijkt het van belang om de patiënt die baat kan hebben bij dit type zorg vroeg te identificeren. Om dit te onderzoeken en om verder te kijken naar andere factoren van invloed op de prehospitale trauma zorg is de DENIM (DElphi studie in Nederland over de Inzet van MMT's) uitgevoerd. Welke laat zien dat communicatie van grote invloed is (Hoofdstuk 6 en 7). Om dit onderwerp verder te onderzoeken is in Hoofdstuk 3 eerst gekeken naar de huidige status van communiceren en overdragen tussen de meldkamer, ambulances en het MMT. Bandopnames van de gehele prehospitale communicatie tussen de meldkamer, ambulance en het MMT werden getranscribeerd en geanalyseerd. Dit onderzoek liet zien dat slecht in 17% van alle gevallen er een compleet situationeel rapport werd over gedragen. Dit kon zijn volgens de Airway-Breathing-Circulation-Disability methodiek (5%), volgens de Situation-Background-Assessment-Recommendation methode (9%) of volgens de Mechanism-Injuries-Signs -Treatment methode (2%). Alle andere overdrachten waren incompleet. De ambulance verpleegkundige ter plaatse is verantwoordelijk voor een duidelijk situationeel rapport. Gebaseerd op deze informatie moet een MMT-arts zich ervan vergewissen of een doorzet van de MMT inzet noodzakelijk is of dat ze veilig kunnen afschalen. Daarom is het overdragen van informatie essentieel voor de continuïteit en kwaliteit en van zorg. Een gestructureerde methodiek voor overdragen kan hierbij helpen. Zoals hierboven ook te lezen bestaan er verschillende acroniemen die de hulpdiensten kunnen helpen bij het geven van een gestructureerde overdracht. In dit onderzoek wordt echter aangetoond dat de huidige modellen maar zeer beperkt worden gebruikt. Verder laten de resultaten van de DENIM (Hoofdstuk 6 en 7) zien dat er vanuit het vakgebied consensus is over het feit dat alleen "ABCD-stabiel" rapporteren niet voldoende is voor een adequate overdracht en dat gebaseerd op alleen die informatie geen gegronde beslissing kan worden genomen. De DENIM laat tevens zien dat er landelijk en onder alle betrokken beroepsgroepen in prehospitale traumazorg behoefte is aan een nieuwe gestructureerde manier van overdragen. Door het standaardiseren van de prehospitale overdracht zal meer patiënt informatie en situationele informatie worden overgedragen waardoor men beter tot een gezamenlijke beslissing komt. Dit zal de kwaliteit van zorg verhogen en mogelijk de uitkomstmaten voor de trauma patiënt verbeteren. En andere conclusie die uit Hoofdstuk 3 kan worden getrokken is dat de implementatie van een nieuw cancel model voor het afschalen van het MMT de informatie overdracht al iets verbeterd. Door het gestructureerd doorlopen van het model wordt meer prehospitale informatie al overgedragen. In Hoofdstuk 4 wordt verder ingegaan op de implementatie van het model. Om hoge percentages onder triage te voorkomen wordt er in Nederland een lage primaire activatie drempel voor de MMT's gehanteerd. Daarom is het belangrijk dat pogingen om over en onder triage te reduceren zich richten op het tweede punt in de keten waar triage plaats vindt. Dit is wanneer de ambulance verpleegkundige ter plaatse komt en deze een eerste professionele inschatting van de situatie kan maken. Gebaseerd op deze, meer gedetailleerde, informatie wordt een beslissing gemaakt om het reeds ingezette MMT door te laten komen of om de inzet te cancelen. In MMT zorg geeft overtriage een verhoging van de kosten, extra veiligheidsrisico's voor het vliegend personeel en verminderde beschikbaarheid van het MMT voor andere, ernstig gewonde, patiënten. The American College of Surgeons heeft gesteld dat de ondertriage maximaal 5-10% mag zijn, met daarbij een overtriage percentage van maximaal 50%. In de regio van de Lifeliner One werd een nieuw cancel model opgesteld omdat het MMT in de oude opzet een hoog cancel percentage had met daarbij een lage voorspellende waarde voor de identificatie, en dus de aanwezigheid, voor de ernstig gewonde trauma patiënt. Prehospitale variabelen werden geïdentificeerd die significant voorspellend waren voor de identificatie van de ernstig gewonde patiënt. Hiermee werd het mogelijk een veilig triage model te ontwikkelen voor het afschalen van onnodige MMT inzetten terwijl de ernstig gewonde patiënt wel de MMT-zorg krijgt die hij of zij behoeft. Hoofdstuk 4 laat zien dat het nieuwe cancel model een hoge accuratesse heeft voor het identificeren van de major trauma patiënt. De sensitiviteit van het model is 0.898 (CI:0.817 tot 0.945), de specificiteit is 0.720 (CI:0.625-0.799). De positief voorspellende waarde is 0.738 (CI:0.648 – 0.812) en de negatief voorspellende waarde 0.889 (CI:0.802- 0.9840). Het model genereert een ondertriage percentage van 10.2% met bijbehorend over triage percentage van 28%. Een cohort voor en na de implementatie van het nieuwe model worden vergeleken. Er wordt gezien dat de gemiddelde leeftijd significant gestegen is in het tweede cohort. Verder is de ISS significant hoger, dit zou kunnen impliceren dat de prehospitale triage beter is werkt waardoor het MMT vaker bij de ernstig gewonde patiënt komt. Het aantal uitgevoerde acute interventies is tevens significant verhoogd, terwijl het aantal patiënten dat moet worden opgenomen op een intensive care afdeling (IC) af neemt. Daarnaast zijn de mortaliteitspercentages vergelijkbaar. Het nieuwe model zorgt ervoor dat de ernstig gewonde patiënt de levensreddende zorg ontvangt van het MMT terwijl het aantal ongerechtvaardigde MMT doorzetten werd verlaagd. Dit onderzoek geeft ons verder ook informatie over de verdeling van de patiëntenstroom vanaf de ongevalslocatie naar de verschillende trauma centra. Drieënvijftig procent van alle patiënten wordt naar een Level 1 trauma centrum gebracht, wanneer we alleen naar de ernstig gewonde patiënten kijken gaat het om 74%. De overige 26% werden voornamelijk naar leven 2 maar ook naar level 3 gebracht.

Hoofdstuk 5 geeft ons een uitgebreid overzicht van de studie opzet van de DENIM (Delphi studie in Nederland over de inzet van MMT's). In de zoektocht naar een antwoord op de primaire onderzoeksvraag: welke acute trauma patiënt heeft baat bij de zorg van een MMT, werd er een nationale digitale Delphi studie opgezet, die drie rondes groot was. Zowel de stuurgroep als het panel van respondenten waren allemaal werkzaam in de pre- dan wel de inhospitale traumazorg. Zoals MMT-artsen, MMT-verpleegkundigen, traumachirurgen, ambulance verpleegkundigen en meldkamercentralisten. Hoofdstuk 6 laat de eerste algemene resultaten zien van de DENIM. Een grote groep van respondenten vulde alle drie de DENIM rondes in. In de eerste ronde was de primaire onderzoeksvraag; welke trauma patiënt heeft baat bij de zorg van het MMT? De eerste ronde werd gebruikt om discussie op te wekken en argumenten te oogsten over dit onderwerp. De antwoorden werden gebruik om onderwerpen te verzamelen voor stellingen die in de volgende ronde werden gepresenteerd. Vanuit de eerste ronde kunnen we concluderen dat het moeilijk is om te identificeren welke patiënt baat heeft bij de zorg van het MMT. Het lijkt problematisch om de ernstig gewonde patiënt te identificeren. Verder blijkt dat de prehospitale communicatie over variabelen zoals vitale parameters voor de ernstig gewonde patiënt schaars en onvoldoende. Daardoor richtte de tweede en de derde DENIM ronde zich verder op de inhoud en kwaliteit van de prehospitale communicatie. Dit omdat er wordt gedacht dat wanneer de prehospitale communicatie duidelijker wordt en meer gestructureerd verloopt we de inzet van een MMT ook beter kunnen evalueren. Dit kan leiden tot betere beoordeling van en ook aanpassingen in de inzet criteria welke leiden tot verbetering in prehospitale zorg. In de tweede ronde werden factoren die invloed hebben op prehospitale communicatie geëvalueerd, er werd gekeken naar essentiële informatie voor een adequate overdracht, factoren die samenwerking beïnvloeden en hoe deze kunnen worden beïnvloed vanuit onderwijs en trainingsperspectief. Vanuit de antwoorden in de tweede ronde werd er toegewerkt naar de derde ronde, deze was gericht op het exact vaststellen van de inhoud van een minimale adequate prehospitale overdracht. Hoofdstuk 7 geeft ons een uitgebreid inzicht in de DENIM communicatie tool een nieuwe methode voor de prehospitale overdracht en hoe deze tot stand is gekomen. Het doel van de studie was het verbeteren van prehospitale communicatie door het genereren van consensus over de exacte inhoud van wat er minimaal moet worden overgedragen in de prehospitale setting tussen meldkamer, ambulance, het MMT en het ontvangende ziekenhuis over een trauma patiënt. De tool bestaat uit een set van 10 parameters die helpen in het structureren van de overdracht, waardoor informatie die essentieel is voor het inschatten van een situatie wordt overgedragen en alle betrokken hulpdiensten een gedegen beoordeling over de situatie kunnen maken.

Het laatste onderdeel van het proefschrift richt zich op de inhospitale trauma zorg voor de ernstig gewonde patiënt. Hoofdstuk 8 onderzoekt de implementatie van een nieuw trauma team activatie model. Hierbij wordt óf het kleine óf het grote trauma team geactiveerd op de shockroom op basis van de vooraanmelding die de ambulance doet bij het ontvangende ziekenhuis. Om de inhospitale triage te verbeteren is er overgestapt van een model met één type team naar een model met twee verschillende trauma teams. Op basis van specifieke prehospitale criteria zoals de vitale paramaters, het mechanisme van trauma of de opgelopen letsels wordt er bepaald of er een klein of en groot trauma team nodig is voor de opvang van de trauma patiënt. Het grote trauma team (GTT) bestaat uit een meer uitgebreide samenstelling van professionals dan het kleine trauma team. De indeling is gemaakt om de over triage te minimaliseren en het oneigenlijk gebruik van middelen te reduceren terwijl de ernstig gewonde patiënt wel wordt geïdentificeerd en de zorg krijgt die hij of zij behoeft. Het lijkt er op dat het nieuwe systeem de ernstig gewonde patiënt die de zorg van het grote trauma team behoeft goed identificeert met een onder triage percentage van 7% en een over triage percentage van 29%. Patiënten werden gegroepeerd in correct grote trauma team, over triage, correct kleine trauma team, onder triage. We vergeleken alle groepen voor inhospitaal overlijden, 30-dagen mortaliteit, duur van opname, IC opname, duur van IC opname. Er werd geen verschil gevonden tussen de groepen. Wanneer we kijken naar de aanvullende onderzoeken die per team warden ingezet was er een ratio te zien van bijna 1:4 voor het totaal (resp. klein trauma team vs. groot trauma team), dit geldt ook wanneer er werd gekeken naar de aanvullende radiologische onderzoeken. Dit impliceert dat er hoger kosten zijn verbonden aan de opvang door een groot trauma team. Verder heeft het de implementatie ertoe geleid dat er meer informatie wordt uitgevraagd en dus wordt overgedragen vanuit de prehospitale naar inhospitale setting. De implementatie van het nieuwe trauma team activatie systeem is slechts een van de vele veranderingen die VU medisch centrum als level 1 trauma centrum heeft doorgemaakt. In Hoofdstuk 9 was het doel te evalueren hoe alle veranderingen in trauma zorg van invloed waren op de uitkomstmaten voor de trauma patiënt in dit centrum. Er werden twee cohorten van traumapatiënten vergeleken, een cohort tussen juni 2004 en juli 2005 en een cohort van het gehele jaar 2014. De vergelijking liet ons zien dat de gemiddelde leeftijd significant omhoog ging, de mortaliteit nam af met 7%, en met een bijbehorende Z-score van 4.25 was de geobserveerde overleving significant beter dan de voorspelde overleving ten faveure van het laatste cohort. Dit impliceert een verbetering in traumazorg in ons centrum.

De vroege identificatie van een ernstig gewonde patiënt, de patiënt die baat kan hebben bij zorg van een MMT, is belangrijk voor het adequaat inzetten en cancelen van een MMT. Echter de identificatie van de ernstig gewonde patiënt blijkt een lastige opgave, dit omdat geen prehospitale casus identiek is en afhankelijk is van enorm veel verschillende factoren. Verder is het een uitdaging omdat de prehospitale communicatie en het rapporteren van variabelen vaak schaars is. Recent zijn er veel verbeteringen gemaakt in de documentatie van prehospitale gegevens in ambulance rapportages en nationale databases, echter wordt deze documentatie vaak pas achteraf gedaan, en niet in het acute moment wanneer de verschillende betrokken hulpdiensten proberen in te schatten welke hulp waar en wanneer nodig is. Het optimaliseren van prehospitale communicatie en de informatie overdracht zal ons daarom dan hopelijk ook een beter inzicht geven in de gang van zaken in de prehospitale setting. Dit proefschrift voorziet in een communicatie tool die kan helpen de prehospitale communicatie tussen alle hulpdiensten te structureren. Het bestaat uit een set van 10 variabelen die in elke prehospitale trauma casus zouden moeten worden overgedragen. Dit proefschrift laat verder de validatie van een nieuw cancel model voor het MMT zien. Dit model helpt in het veilig cancelen van een MMT wanneer deze primair is ingezet. Het model identificeert de ernstig gewonde patiënt terwijl ongerechtvaardigde MMT inzetten veilig kunnen worden gecanceld en de mortaliteitscijfers laag blijven.

List of abbreviations

ABCDE: acronym for method of reporting (Airway Breathing Circulation Disability Exposure)
ABG: arterial blood gas
ACS: American College of Surgeons
AIS: abbreviated injury scale
ALS: advanced life support
AMPDS : Advanced dedical priority dispatch system
ANWB: Algemene Nederlandsche Wielrijders-Bond, Royal Dutch Touring Club
ASCOT: a severity characterization of trauma
ASDH: acute traumatic subdural hematoma
AT: activation time
ATLS : advanced trauma life support
AVPU: acronym for measurement of patient's level of consciousness (alert, voice, pain, unresponsive)
BD: base deficit
BLS: basic life support
BP: blood pressure
BSA: burn surface area
CIA: Confidence interval analysis
CT: computerized tomography scan
CTT: complete trauma team
CUPS: critical/unstable/potentially unstable/ stable-tool
DALY: disability-adjusted life years
DC: dispatch center
DENIM: DELphi studie in Nederland naar de Inzet van het MMT, a Delphi-procedure on the identification of trauma patients in need of care by P-HEMS in the Netherlands
DOA: dead on arrival
DOH: department of health
EBL: estimated blood loss
ED: emergency department
EI: endotracheal intubation
EMS: emergency medical services
EMV: eye, movement, verbal
ER: emergency room
FAST: focused assessment with sonography in trauma
FL: Flevoland
GCS: Glasgow coma scale
GTT: General trauma team
GV: Gooi & Vechtstreek
HEMS: helicopter emergency medical services
HR: heart rate

ICH: Intracerebral hemorrhage
ICU: intensive care unit
IMIST-AMBO: acronym for method of reporting(Mechanism/medical complaint, Injuries/ information relative to the complaint, Signs, vitals and GCS, Treatment and trends/response to treatment, Allergies, Medications, Background history and Other (social) information)
ISS: Injury Severity Score
KL: Kennemerland
LL1: Lifeliner One
LOS: hospital length of stay
MAPH: Minimal adequate prehospital handover
MIST: acronym for method of reporting (Mechanism Injuries Signs and Treatment)
MMT: mobile medical team
MOI: mechanism of injury
NHN: North Holland North
NPV: negative predictive value
NTD: national trauma database
NTS: Nederlands triage system (Dutch triage system)
NVI: non vascular injuries
OSP: on-scene physician
OST: on-scene time
PASG pneumatic anti-shock garments
P-HEMS: phycisian staffed helicopter emergency medical services
POS: probability of survival
PPV: positive predictive value
ProQA: Professional quality assurance
PTLS: prehospital trauma life support
RR: "Riva-Rocci" abbreviation for blood pressure
RT: response time
RTD: regional trauma database
RTDB: regional trauma database (
RTS: revised trauma score
SAH: subarachnoidal hematoma
SBAR: acronym for method of reporting (Situation Background Assessment Recommendation)
SBP: systolic blood pressure
SD: standard deviation
SitRap: situational report
SOAP: subjective, objective, assessment, plan
SP: stay and play
SR: scoop and run
SSA: Shared situational awareness
STT: selective trauma team
TBI: traumatic brain injury

TOI: time of incident
TPT: total prehospital time
TRISS: trauma and injury severity score
TRNWN: Trauma Region North West North
TS: trauma score
TT: transfer time
TTA: trauma team activation
US: ultrasound
X: x-ray

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Pro·fes·sor Bon·jer

[Prof.B]

Hoogleraar in de chirurgie en hoofd van de afdeling chirurgie VU medisch centrum

Promotor

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Dr·F·W·Bloe·mers MSc

[Frank]

Hoofd van de afdeling trauma chirurgie, traumachirurg van Ajax

Co-promotor

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O·ve·ri·ge·le·den·van·de·pro·mo·tie·com·mis·sie

[Prof Schipper, Prof Edwards, Prof Verhofstad, Prof Breederveld]

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Dr·G·F·Gian·na·ko·pou·los

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AIOS chirurgie, gepromoveerd op het gebied van prehospitale traumachirurgie en triage

Co-promotor

Lieve G, mijn grote onderzoeksbroer! Eerste meeting op de chirurgendagen, kan het me nog heugen, ik dacht alleen maar “hoe ga ik die naam onthouden?”. Het was het begin van een nieuw dynamisch trauma research duo. Samen brainstormen over projecten en vraagstukken. Vele uren discussiëren/redigeren en uiteindelijk staat het ook nog allemaal op papier. Zonder jou had ik hier niet gestaan. Los van alle onderzoekskills die je me geprobeerd hebt bij te brengen ben ik je dankbaar voor de persoon die je bent, het fijne geborgen gevoel en de vriendschap die je me hebt gegeven. Jij was er om me gerust te stellen als ik weer eens harder wilde dan ik kon, je dacht mee over m’n toekomst/onderzoek en probeerde samen met mij tot een mooie weg te komen. Je bent een topper en ik weet zeker dat je gaat doen waar je van droomt. Feit dat ik ons professionele pad verlaat wil niet zeggen dat ik daarmee onze vriendschap ook uitzwaai, die houd ik vast.

Dr·J·Straat·man MSc

[J]

Andere helft van team awesome

Lief vriendinnetje

Motivator. Diegene die mij bij mijn kladden pakte, diegene die mij zo ongeveer bij mijn nekhaar pakte en bij van der Peet op zijn kamer neerzette. Bedankt voor alles wonder woman, mijn waardering is enorm! Feit dat ik naast jou mocht staan en jij naast mij wilt staan, zegt voor mij alles. Maar vooral bedankt voor je vriendschap en steun, je bent een topper.

Drs·A·N·Nie·mei·jer

[Anna-L]

AL de tweede

Brakke makker vanaf dag 1

Lief vriendinnetje, bedankt voor je gesprekken, je steun, je kritische blik op mijn stukken, de gezellig koffietjes, creatieve wijn-sessies, relativerende mening en mooie momenten die we samen hebben gehad. Heel bijzonder dat we dit konden delen. Let the games continue!

Pro·fes·sor·van·der·Peet

[VanderP]

Hoogleraar in de GE chirurgie VU medisch centrum

De kans gever. Beste professor, heel erg bedankt voor al de kansen die u mij heeft geboden. Het begon met onderzoek doen naar de toegevoegde waarde van het CRP samen met Jen. Mijn eerste echte stappen in de chirurgische wetenschappelijke wereld. Gelukkig rekende u het mij niet al te erg aan dat ik traumachirurgie ietsjes interessanter vond dan GE chirurgie en stelde mij voor aan Frank om daar het onderzoek verder op te pakken. En ook stelde u mij in staat mijn klinische vaardigheden uit te breiden en een goed beeld van het vak te krijgen. Maar bovenal ben ik u zeer dankbaar voor de vele gesprekken die we hebben gehad omtrent toekomst en opleiding. Ik waardeer uw openheid, het meedenken en ook de spiegel die u mij voor houdt.

Dr·L·M·G·Gee·raedts·jr·MSc

[Leo]

Traumachirurg VUmc, voormalig lid MMT lifeliner 3

Co-auteur

Mentor. Beste Leo, bedankt voor al je hulp in het tot stand komen van dit boekje. Maar ook alles daarbuiten. Bij jou op de rode bank zitten luisteren naar je MMT verhalen is iets waar ik enorm van heb genoten en mij heeft geënthousiasmeerd hier nog harder voor te vechten. Je oprechte interesse en constante bereidheid hulp te bieden en mee te denken aan projecten zijn dingen die ik niet zal vergeten. Dank je wel

Dr·L·B·Mok·Kink

[Wieneke]

Post-doc onderzoekster afdeling Epidemiologie en biostatistiek VUmc

Delphi master

Lieve Wieneke, je enorme kennis en kunde op het gebied van epidemiologie hebben de DENIM tot een succes gemaakt. Verrassend om iedere keer met je te zitten en te brainstormen over de beste aanpak. Hierbij bracht jouw compleet andere kijk op zaken mij telkens weer zo veel verder. Bedankt voor al je hulp.

Dr·H·M·T·Chris·ti·aans

[Herman]

Chief doctor Lifeliner 1, Anesthesist VU medisch centrum

Raadgever. Beste Herman, allereerst bedankt dat jij mij als vreemde eend van de heelkunde toeliet in jullie warme MMT-nest. Je hebt me vanaf dag één op een enorm fijne en positieve manier gesteund in de ideeën die ik had. Ik heb genoten van je visie op het vak, op het onderzoek en op welke richting de prehospitale zorg zich ontwikkelt. Door jou staan de deuren nu ook open richting de andere lifeliners. Ik hoop dat je enorm gaat genieten van je "post-chief-doctor" fase!

Dr·M·Ter·ra

[Maartje]

Traumachirurg, MMT-arts, sport traumachirurg

Lieve Maartje, stiekem bewonder ik jou. Zoals jij multi-taskend door het leven gaat en ervan geniet. Je bent traumachirurg, sport trauma chirurg, MMT-arts, mamma en echtgenoot, en nog veel meer. Ook de manier waarop jij met patiënten omgaat is er een waar ik veel van wil leren. Verder ben ik enorm blij met je hulp in het ontwikkelen en het lezen van veel van mijn onderzoeken, met je relativerende blik op het leven, voor de gezellig avonden en voor het goedkeuren van mijn outfit als ik weer eens niet wist hoe sjiek ik gekleed moest voor een congres. Bedankt dat je mij meenam op de big bird, beste dag ooit!

Drs·T·H·Bies·Heu·Vel

[Tes]

Chirurg, MMT-arts, Medisch hoofd SEH VUmc

Lieve Tessa, bedankt voor de fijne samenwerking. Jij was de brug tussen de heelkunde, de spoed en het MMT onderzoek. Bedankt voor het openen van de deuren. Maar bovenal bedankt voor al het lachen en de mooie momenten.

Ook de overige leden van het MMT van de Lifeliner 1 ben ik veel dank verschuldigd. Ik wil jullie heel graag bedanken voor alle hulp bij de verschillende onderzoeken. Bedankt dat jullie openstonden en bereid waren mee te werken. Patrick, bedankt voor het meedenken over de opzet van de studie, jouw input heeft de Cancel studie verder geholpen. Sjoerd bedankt voor je kritische blik en input bij de opzet.

Ook aan alle andere co-auteurs ben ik veel dank verschuldigd. Prof Goslings, Gaby Fransman, Kaoutar en alle anderen. Bedankt voor het meeschrijven, het redigeren en jullie deelname aan het hele proces.

Lieve Bas, waar een gezamenlijke liefde voor Jamie Woon mij al niet brengt. Ik ben jou zo enorm erkentelijk dat je my editor-in-chief wilde zijn. Door jou is het mooi!

Dear Azhar, a special thanks to you for blue-penciling my manuscript and helping me bring the level of English up.

Bedankt ook aan de chirurgen en (oud) fellows van de afdeling traumachirurgie. Beste Wieste, Jaap, Jesse, Matthijs en Charlotte. Bedankt dat ik bij jullie de basis van level 1 traumatologie heb mogen leren.

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Verder wil ik graag het Netwerk acute zorg voor al haar steun. In het bijzonder Annelies Toor, dank voor al je hulp in het verzamelen van data.

De overige chirurgen en assistenten chirurgie in het VU medisch centrum. Ik vond het fijn met jullie te werken. Bedankt voor alle leerzame momenten en ook de gezellige borrels. In het bijzonder Has, thanks bro voor alles, ik hoop op nog veel goede gesprekken. En ook Ramon, bedankt voor het fijne/open gevoel dat je creëert (ook aan Mutti), ik waardeer jullie steun enorm.

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Lieve Harmsens: Lieve Rein en Non, sibs en gekkies van het eerste uur. Maar vooral de meest briljante en lieve broer en zus die ik me kan wensen. Zussie, bedankt voor je steun, je fijne woorden als ik er soms doorheen zat, je motiveert en relativeert. Kleine grote Rein, bedankt voor het geborgen gevoel dat jij mij geeft, bij jou voel ik me thuis. Laten we nog lang met z'n drieën tandemfietsen!
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Curriculum Vitae

Annelieke Maria Karien is geboren op 8 september 1987 te Ouderkerk aan de Amstel. In 2006 behaalde zij haar atheneum diploma aan Het Keizer Karel College te Amstelveen. Waarna zij in september 2007 begon met de opleiding Geneeskunde aan de Vrije Universiteit te Amsterdam. Als onderdeel van haar opleiding deed zij haar semi-arts stage bij de afdeling chirurgie van het Rode kruis ziekenhuis te Beverwijk. Alhier raakte zij bevlogen van de chirurgie en groeide haar affiniteit voor de trauma chirurgie. Onder begeleiding van prof Breederveld zette zij voorzichtig haar eerste stappen in de wereld van onderzoek door een database over heupfracturen op te zetten. Aansluitend volgde er een onderzoekstage naar de voorspellende waarde van het C-reactief proteïne na abdominale chirurgie op de afdeling chirurgie in het VUmc onder begeleidging van prof. dr. MA Cuesta & prof. dr. DL van der Peet. Dit leidt uiteindelijk tot twee publicaties en deed haar enthousiasme voor onderzoek nog meer vergroten. Tijdens haar studie ontdekte ze naast haar liefde voor trauma chirurgie een interesse voor de acute geneeskunde en in het bijzonder de levensreddende zorg die door het Mobiel Medisch Team wordt geleverd. In september 2013 is zij direct na het behalen van haar diploma gestart met een promotie traject waarin zij al deze facetten kon combineren. Dr Frank Bloemers stelde haar in staat om samen met Georgios Giannakopoulos een onderzoekslijn op te zetten over de prehospitale trauma zorg die het Mobiel Medisch Team levert. Na twee jaar fulltime aan het promotie onderzoek te hebben gewerkt en deze op meerdere nationale en internationale congressen te hebben gepresenteerd, startte zij in september 2015 als ANIOS chirurgie in het MC Slotervaart. Om haar klinische vaardigheden verder uit te breiden is Lieke daarna kort aan de slag gegaan als ANIOS chirurgie in het VU medisch centrum. Om ondertussen haar proefschrift af te ronden.

Appendix 1

Dispatch criteria based on the state of the patient

Consciousness:
Unconscious: yes or no?
This is the primary question which combined with more specific conditions as listed below assesses the need for P-HEMS dispatch

A(irway):
Acute threatened airway which will require intubation
- head/neck injury
- edema, for instance angio edema in case of a anaphylactic reaction
- foreign body
- suspicion of inhalation injury
- stridor
- burns in the head-/neck area

B(reathing):
- acute respiratory failure, intubation and ventilation under medication indicated
- every patient with sever deviations in the breathing frequency:

Age	Breathing frequency
<1	<20; >50
2 – 5	<15; >40
5 – 12	<10; >35
> 12	<10; >30

- thoracic trauma with O2 saturation <96%, despite administration of 100% O2 for 5 minutes

C(irculation):
- (suspicion of) CPR, in which the first ambulance cannot be at the scene < 10 min
- persistent shock ≥ class III
- circulatory failure for witch repeated administration of vasoactive medication is required (impending circulatory arrest)

Note: excluded are cases of uncomplicated primary adult resuscitation; the so called out of hospital cardiac arrest

D(isability):

- unconsciousness or decreasing awareness during contact with patients (GCS ≤ 8)
  Note: A GCS <8 is an unconscious patient with potentially endangered A and B with residual reflexes
- (imminent) paraplegia
- status epilepticus unresponsive to medication according to protocol, expansion of medication and treatment is necessary
- patients who require advanced pain treatment

E(xposure):

- high-energy injuries with (open and / or closed) fractures of femur, pelvis, or spine
- gunshot wounds, severe beating or stabbing wounds on skull, thorax or abdomen
- scoop and run for medical / surgical assistance; (chest drainage or thoracotomy prehospital can be lifesaving)
  Note: Consider rendezvous between ambulance and P-HEMS.
- burns> 15% BSA (body surface area)
- (patients with burns indication)
- patients with severe hypothermia <32 gr. Celsius core temperature, who have an indication for extracorporeal support, or at risk of developing
  to expect from the indication

Dispatch criteria based on the distress call related to the state of the patient (nature event)

- accident with large vehicle such as; train / tram / truck / bus / plane / ship
- accidents with vehicles at high speed in which:
  - » victim is ejected and / or
  - » multiple injured and / or deceased passengers
  - » entrapment, burial or drowning
- accidents involving electricity (incl. Lightning)
- explosion
- chemical, toxic or nuclear incidents in which advanced medical expertise and treatment is required, which is outside LPA 7.1
- intoxication with industrial toxins (e.g. agricultural pesticides) whether or not in case of in the context of an attempted suicide
- large fire with entrapped victims
- diving accidents, in which medical expertise in handling and during transport to a diving medical center is needed
- obstetric complications

Note: in case of doubt and in particular, when a child is involved an the DC may dispatch the P-HEMS

Dispatch criteria based on logistical factors

- EMS arrival at given address / location takes longer than 20 minutes
- location of accident difficult or unreachable by road

The most desirable form of transport of the patient to the hospital is depends on several operational factors:

- condition of the patient and associated time constraints for clinical intervention
- availability of the helicopter
- weather conditions
- distances
- landing capabilities at hospitals
- traffic situation

Because these factors may vary per dispatch the P-HEMS team will consider them for each dispatch independently and make a decision in consultation with the other emergency services.

In general it can be stated that the transport of a patient via helicopter should be beneficial in time reduction for:

- the treatment of the patient and the associated prognosis
- the availability of the P-HEMS team for new dispatches

Cancel criteria

- vital functions(ABCD) are normal:
- RTS =12
- EMV = 15
- no deterioration is to be expected within 1 hour
- victim is deceased
- false distress call
- there is an indication for “scoop and run” (A and B are stable, though C is unstable), P-HEMS should be consulted to consider a rendez vous

Appendix 2

Strobe checklist for the assessment of the risk of bias

Strobe items	Báez	Brooke	Dinh	Eachempati	Feero	Funder	Gonzalez	Härtl	Honigman	Kidher	McCoy	McGruffie	Newgard	Osterwalder	Pepe	Petri	Ringburg	Ryb	Swaroop	Tien
1a Indicate the design with a commonly used term	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
1b In abstract provide an informative summary	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2 Explain the scientific background and rationale	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3 State specific objectives and hypotheses	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4 Present key elements of study design	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5 Describe the setting, locations, and relevant dates	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	no	Yes	Yes	Yes
6a Give the eligibility criteria	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	no	Yes	Yes	Yes	Yes	Yes
6b For matched studies, give matching criteria	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
7 Define outcomes, exposures, confounders, s	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	no	Yes	Yes	Yes	Yes	Yes
8 For each variable, sources of data and assessment method	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9 Describe any efforts to address potential sources of bias	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
10 Explain how the study size was arrived at	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11 Explain how variables were handled in analyses	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12a Describe all statistical methods	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	no	Yes
12b Describe methods to examine interactions	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12c Explain how missing data were addressed	No	Yes	Yes	No	Yes	No	No	No	No	No	Yes	No	Yes	No	No	No	Yes	Yes	No	Yes
12d explain how loss to follow-up was addressed	n.a.	n.a.	n.a.	n.a.	n.a.	No	No	Yes	No	n.a.	No	n.a.	n.a.	No	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
12e Describe any sensitivity analyses	Yes	yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13a Report numbers of individuals at each stage of study	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes
13b Give reasons for non-participation at each stage	No	Yes	Yes	No	No	Yes	No	No	No	No	Yes	No	Yes	No	No	No	No	No	No	Yes
13c Consider use of a flow diagram	Yes	No	No	No	No	No	No	No	No	No	Yes	No	Yes	No	No	No	No	No	No	Yes
14a Give characteristics of study participants	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14b Indicate number of participants with missing data	No	Yes	No	No	No	Yes	Yes	No	No	No	Yes	No	Yes	No	No	Yes	Yes	Yes	No	No
14c Summarise follow-up time	n.a.	n.a.	No	n.a.	n.a.	Yes	n.a.	Yes	No	n.a.	No	n.a.	n.a.	No	n.a.	Yes	n.a.	n.a.	n.a.	n.a.
15 Report numbers of outcome events	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes
16a Give unadjusted estimates	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
16b Report category boundaries	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
16c Consider translating estimates of relative risk	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
17 Report other analyses done	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
18 Summarise key results	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
19 Discuss limitations, potential bias	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
20 Give a cautious overall interpretation of results	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
21 Discuss the generalisability	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
22 Give the source of funding	No	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Appendix 3

Search strategy in Pubmed,
update on May 19th 2014.

Set	Search terms	Result
#5	#4 AND ("Evaluation Studies"[Publication Type] OR "Cohort Studies"[Mesh] OR cohort[tiab] OR observational[tiab])	1314
#4	#1 AND #2 AND #3	2193
#3	"Patient Admission"[Mesh] OR "Length of Stay"[Mesh] OR "Mortality"[Mesh] OR "Injury Severity Score"[Mesh] OR "Glasgow Coma Scale"[Mesh] OR "Hospital admission"[tiab] OR "admission duration"[tiab] OR "In hospital time"[tiab] OR "ICU admission"[tiab] OR death rate*[tiab] OR "Revised trauma score"[tiab] OR "glasgow coma"[tiab] OR "coma scale"[tiab] OR "coma score"[tiab] OR "gcs"[tiab] OR "Injury severity score"[tiab]	386535
#2	"Time Factors"[Mesh] OR "Time-to-Treatment"[Mesh] OR "scene time"[tiab] OR OST[tiab] OR Time-to-Treatment*[tiab] OR "Response interval"[tiab] OR "Response time"[tiab] OR "access interval"[tiab] OR "assessment interval"[tiab] OR "treatment interval"[tiab] OR "patient removal"[tiab] OR "patient interval"[tiab] OR "Transport interval"[tiab] OR "Transport time"[tiab] OR "Delivery interval"[tiab] OR "pre hospital time"[tiab]	995690
#1	"Emergency Medical Services"[Mesh:NoExp] OR "Advanced Trauma Life Support Care"[Mesh] OR "Emergency Service, Hospital"[Mesh] OR "Transportation of Patients"[Mesh:NoExp] OR "Ambulances"[Mesh] OR "Emergency Treatment"[Mesh:NoExp] OR "Emergency Medical Technicians"[Mesh] OR (("emergency medicine"[tiab] OR emergency service*[tiab] OR Emergency Mobile Unit*[tiab] OR Mobile Emergency Unit*[tiab] OR P-HEMS[tiab] OR "mobile medical team"[tiab] OR HEMS[tiab] OR helicopter*[tiab] OR ambulance*[tiab] OR transport*[tiab] OR transfer*[tiab] OR paramedic*[tiab] OR emergency centre*[tiab] OR emergency center*[tiab] OR "emergency care"[tiab] OR "trauma care"[tiab] OR "Emergency Treatment"[tiab]) NOT medline[sb])	198807

Appendix 4

Additional questions on methods for handing over from round 1 and 2 in the DENIM study

Statement	Consensus	Arguments
It is justified to accept an incomplete MIST for a handover	T- (64%)	- professional should be able to at least provide the information requested in a MIST - that the wrong conclusions could be drawn from an incomplete MIST - that a full report of the situation is needed in order to transfer reliability of care
There is a set method for handing over between EMS and P-HEMS: MIST	T+ (62%)	
There is a set method for handing over between EMS and P-HEMS: SBAR".	N	
There is no set method for handing over between EMS and P-HEMS".	T- (63%)	
There is need for a set method for handing over between EMS and P-HEMS	T+ (69%)	
Reporting ABCE-stable is to brief for a minimal adequate handover	T+ (76%)	
It is useful to write down what the exact content should be of a minimal adequate handover	T+ (91%)	